A Strategic Overview
Hazardous Goods Transportation by Rail in Toronto

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EXECUTIVE SUMMARY

An overview was carried out of the 44 kilometers of rail corridor making up the box-shaped network that has served Toronto for 100 years (see Section 1.5, Chapter 1). This review responded to community concerns over a perceived hazard from the transport along these lines of dangerous commodities (DCs) and special dangerous commodities (SDCs). SDCs are DCs that must be handled with special care.

Initial study findings indicate that:

- Rail traffic on the Toronto rail system (see Section 2.2, Chapter 2) demonstrates the respective orientation of the two railways, with heavy east-west freight movements on CP rail and heavy east-west passenger traffic on CN lines.

- In 1985 the three most heavily transported dangerous goods consisted of (CP Rail data):

  . propane - flammable compressed gas (about nine carloads daily),
  . styrene - flammable liquid (about three carloads daily),
  . methanol - flammable, poisonous liquid (about three carloads daily).

- The subdivisions with the heaviest DC/SDC volumes (i.e. North Toronto, Mactier and Galt subdivisions) have average daily volumes ranging from 30 to 75 DC carloads, with SDC loads averaging from six to 17 carloads per day (1985 averages).

- DC traffic patterns in Toronto by type and volume fluctuate considerably from year to year.

- DCs and SDCs together make up about 3% to 4% of all freight traffic, SDCs alone are about 0.5% to 1% of total freight traffic.

- Those subdivisions with the heaviest DC volumes (i.e. North Toronto, Mactier, and Galt subdivision at West Toronto Yard) carry approximately 80% through volumes (i.e. passing through Toronto CMA).

- Operational safety conditions for DC/SDC transport by rail are high, particularly in comparison with other transport modes (i.e. historically no deaths in Toronto have resulted from a rail release of DC or SDC).

- Over the past five years the railway industry has undergone a major retrofit of tank cars and installation of advanced monitoring equipment for safety purposes.

- In terms of both probability and extent of impact, three types of independent DC events pose a particular danger--pool fires, BLEVEs and toxic gas releases. (A BLEVE is a major compressed gas explosion).

- The combined probability of any one of these three incidents occurring along the Toronto rail system is estimated to occur once in 800 to 1500 years.

Hazard Profile Analysis

A special investigation was made of 'hazard profile' along the Toronto rail lines. This examined all attributes of rail traffic hazard potential including DC traffic, line features, population density, evacuation capability, topography, and proximity of vulnerable institutions.

This assessment found that certain lines combined heavy DC flows, accident probabilities, population densities and features vulnerable to accident effects. These sections are designated 'Special Hazard Sections' and include:

- Galt subdivision at West Toronto Yard,
- Mactier subdivision,
- North Toronto subdivision.

In carrying out the Hazard Profile assessment, two consequence zones were defined along rail corridors representing the extent of accident impacts. These included a High Consequence Zone (HCZ) and a Medium Consequence Zone (MCZ) (see Section 2.6, Chapter 2). It was found that 50% of Toronto's population was located in these zones, and that some 28% of the population was located in the consequence zones of the Special Hazard Areas. (Note: An individual rail accident would likely affect only a small fraction of this population.)

ISSUES

In assessing the significance of rail safety within the City of Toronto two critical questions were addressed.

- the extent of existing public hazard,
- the importance of relief of the exposure of population in Toronto to dangerous goods traffic.

These issues are discussed briefly as follows:

- **How Serious is the Level of Hazard**

A critical question in this review is whether the present and future hazard, to which the City's population is subjected as a result of rail transport of DC traffic, is acceptable or unacceptable. The answer to this question could necessitate major risk management initiatives.

As referred to above, the probability of one of the three most critical accident types (pool fire, BLEVE, and toxic gas discharge) occurring on rail lines within Toronto is estimated to occur once in 800 to 1500 years. These specific incidents upon occurrence can threaten the safety of up to thousands of people with impacts extending up to greater than a square kilometre.

It is apparent that DC rail incidents have a very low probability of occurrence but under the worst circumstances can have very heavy consequences. In assessing the seriousness of hazard, two additional factors need consideration.

The factor of uncertainty, whereby a number of uncertain elements may affect hazard potential.

- Probability forecasts depend upon a variety of statistical sources, each affecting the accuracy of predictions.

- The accident analysis is based on a maximum DC release. The release of smaller volumes would result in a higher probability level with a correspondingly smaller area of impact.

- Future volumes and types of transported DC are unpredictable resulting in higher or lower hazard potential.

- Certain conditions bearing on safety are of concern, i.e. .
  - engineering standards of containers
  - storage of DCs on private lands near rail lines
  - access of trespassers to rail rights-of-way.

The factor of concentration, whereby those rail sections with high population concentrations and accident vulnerability occur in corridors having the highest risk probabilities due to relatively high volumes of DC transport (i.e. Special Hazard Sections, Section 2.9, Chapter 2).

The above information provides a picture of the level of public hazard in Toronto associated with DC transport by rail. It is hoped that City authorities can assess these conditions in relation to other municipal hazards and concerns in deciding upon the degree of urgency and priority for action in addressing these conditions.

- **Need for Diminished Exposure**

Over 300 000 residents are located in the consequence zones of all of the City's rail lines. As well, over 200 000 residents are included in the consequence zones of those rail sections carrying some 90% of all dangerous or special dangerous commodity traffic carried in Toronto. (Individual accidents would, of course, affect only a small fraction of the above numbers of people.)

Another relevant consideration is the increasing numbers of high density, multiple-use land developments located along the rights-of-way of rail lines carrying relatively heavy DC volumes. Although the City should re-examine its zoning policies with an eye to regulating land uses along rail corridors, it is likely that the only effective means of totally protecting existing exposed high-density developments is by diverting special dangerous commodities (SDCs) to some hypothetical protected corridor.

Accordingly, there would appear to be both a public safety motive for achieving minimal public exposure to DC/SDC traffic, and a public economy motive for espousing a diversionary or rerouting option. That is, the removal of through DC traffic would diminish the need for constraining land uses along rail corridors. It should be noted that the City might be required to contribute to the capital cost of any diversion or bypass option.

OBJECTIVES

In defining and assessing risk management measures for rail DC transport, eight objectives were defined.

1. To manage the transport of dangerous commodities so as to optimize public safety in general (i.e. where possible, to minimize or eliminate the impact of a serious incident by means of a variety of risk management measures).

2. In achieving Objective No. 1, to minimize, where possible, the hazardous exposure of the public to dangerous commodity transport (i.e. to remove them from proximity to each other).

3. Since rail is the safest available mode of land transport, to avoid diverting freight from rail to truck transport.

4. To sustain the competitive efficiency of rail freight operators in this area.

5. To enhance the performance of industrial and commercial enterprises in Toronto.

6. To avoid transferring the transport of dangerous commodities from Toronto so as to introduce a threat to other communities.

7. To achieve a cost-effective solution in terms of total benefits and costs.

8. To achieve a solution compatible with the social, physical, and service environment of the adjacent community.

ALTERNATIVE MEASURES

The other side of identifying potential DC transport hazards is the question of what can be done to alleviate existing levels of hazard potential. A preliminary review of alternative measures was carried out and a total of 33 specific risk management initiatives were identified. These were assessed under the following categories.

A. Enhancing Existing Operations

This category assesses the large area of operational and mechanical changes ordered by the RTC following the Mississauga accident. Additional measures discussed ranged from yard safety to the better provision of rail operating data, including the future use of Advanced Train Control Systems.

B. Minimizing Traffic Impacts

These include strategies designed to decrease the exposure to or impact of DC traffic incidents. These cover both long-term and short-term effects and range from scheduling revisions to land use zoning changes.

C. Reducing DC Traffic

This includes the opportunities for diverting or minimizing DC trips within the City of Toronto, and includes a number of route bypass alternatives.

EFFECT OF RISK MANAGEMENT PROGRAMS

Impact on Railways

The implications of implementing four specific risk management initiatives concerning the railways is summarized as follows:

- Prioritized Risk Management - These measures will likely be applied to the more heavily travelled CP Rail lines. At present, CP Rail applies high safety priority to these lines, and a prioritized approach would likely represent an intensification of what is already underway, plus input from the municipality and the RTC.

- Speed Constraints - The continuation of 25-mph speed limits for certain heavy SDC traffic corridors is considered by the railways to adversely affect rail operations in the following ways:

  - reduces customer service by hampering 'just in time' service,
  - limits train scheduling by hampering inter-route connections,
  - less capacity as a result of congestion on heavily used lines,
  - increased equipment and manpower requirements.

- DC Traffic Prohibition - Various bans on DC/SDC shipments would cause serious disruption and cost increases in train routing and scheduling.

- Bypass - A major diversion or bypassing of DC or all through traffic could apparently only be achieved by a major restructuring of rail operations in this area at great cost and disruption. A diversion of the relatively small volumes of SDC shipments to existing routes would generate strong opposition from the communities affected, as well as requiring restructured rail routes and operating procedures.

Impact on Community

The implications for the City of Toronto from risk alleviation measures is summarized as follows.

- Enhanced Safety - Any mitigation of risk ranging from basic operational and equipment initiatives to major diversions, would achieve the prime objective of decreased public hazard and greater protection of life, limb and property. An effective DC traffic diversion would achieve the goal of minimized public exposure to DC traffic.
- Effect on Industry - The City should be aware of the possible influence of major rail traffic shifts upon those industries depending upon rail access. A major diversion might tend to attract industry to peripheral sites. Any shift of freight from rail to truck would increase public hazard.
- Land Use Controls and Development - DC traffic diversion could diminish the need for restrictive zoning in rail corridors thus ensuring the opportunity to respond to land development proposals. As well, properties in less active rail yards could possibly become available for development. Railways oppose residential development along rail corridors, primarily because of the potential hazards of rail car dispersion in accidents.

- o Passenger Rail Services - A major diversion from east-west rail freight routes would allow consideration of opportunities for the use of these lines for rail passenger services.

- o Financial Implications - the City should not ignore possible obligations for significant capital contributions to major rail traffic diversion schemes.

- o Speed Restraints - While speed restrictions down to 25 mph may provide safety improvements, lower speeds may generate increased noise and vibration in adjacent neighborhoods.

AN INTEGRATED PUBLIC SAFETY PROGRAM

It is recommended that the City focus its resources on the development of an overall public safety program by integrating a number of existing activities. Such a program should be prepared in close cooperation with other agencies [i.e. RTC, Province of Ontario, the Railways, industry, Metropolitan Toronto Emergency Planning Advisory Committee (MTEPAC), citizens' groups] and should include the following components:

- . implementing a prioritized risk-management strategy,
- . land use control measures,
- . rail rights-of-way security,
- . emergency response,
- . rail operating data sources.

SPECIFIC RECOMMENDATIONS

A number of specific recommendations are listed below concerning required action by the respective authorities for expediting the implementation of risk management measures in Toronto. These are categorized as follows

1. Immediate or Short-Term Measures
   - special hazard sections
   - all rail sections.

2. Long-Term Measures.

3. Operational and Administrative.

4. Recommendations of the Federal Task Force.

1. Immediate or Short-Term Measures

Special Hazard Sections. These have been designated in the hazard profile assessment (Chapter 2) to include the North Toronto, Mactier, and Galt (west of West Toronto Diamond) subdivisions which justify special safety measures including the following recommendations.

(a) That the Province of Ontario (Ministry of Transportation and Communications) and the City of Toronto request that the Government of Canada ensure that the request to Treasury Board be met for the provision of additional RTC inspectors for monitoring and surveillance of rail operations in the Toronto Region.

(b) That the City of Toronto request the RTC to investigate the best means of eliminating or sharply curtailing the through movement of SDC tank cars on the Toronto Terminals Railways.

(c) That the City of Toronto request the RTC, in cooperation with the railways, to investigate the use of extended Jordan Guard Rails to confine derailments in special hazard sections.

(d) That the City of Toronto request that the railways, working with Metro Police, develop a program of special security measures to discourage trespassing and vandalism on rail rights-of-way on special hazard sections.

(e) That the City of Toronto request the RTC to apply speed restrictions proposed by the Federal Task Force, following their assessment of their effects, to the special hazard sections as required.

(f) That the MTEPAC organization recognize the needs of the special hazard sections of the City's railway lines and yards and ensure that response procedures are in place.

Overall Rail Network in Toronto

(g) That the City of Toronto request that the Province of Ontario (Ministry of Transportation and Communications) and the Government of Canada (Transport Canada) approve the construction of a grade separation at the Strachan Avenue level crossing.

(h) That the Province of Ontario (Ministry of Consumer and Commercial Relations) and the RTC, working with the City of Toronto, establish effective authority and procedures for the control of bulk storage of DCs on private lands adjacent to rail corridors.

(i) That the Province of Ontario (Ministry of Labor) effect suitable legislation to ensure the availability of information on the storage of DCs for use by municipal emergency response personnel.

(j) That the MTEPAC organization in planning and effecting emergency response measures work closely with the railway companies, the RTC, the chemical industry and the trucking industry.

(k) That the City of Toronto (Department of Planning and Development) investigate suitable short-term land use regulatory measures for rail corridors.

2. Long-Term Measures

(l) That the City of Toronto (Department of Planning and Development) following the resolution of long-term plans for rail DC traffic in the Toronto area, establish suitable land-use regulatory measures for rail corridors.

3. Operational and Administrative

(m) That the City of Toronto request that the RTC set a high priority on assessing the need for safer engineering standards of containers and supporting vehicles for DC transportation by rail.

(n) That the Government of Canada and the railway companies pursue with all deliberate speed the possible use of Advanced Train Control Systems on special hazard sections in Toronto.

(o) That the Government of Canada (Transport Canada) investigate the provision of rail system operating data for use in emergency response planning and the general investigation of DC rail transport in urban areas.

(p) That the City of Toronto request that the RTC assess the potential advantages of operating designated DC trains in built-up areas, including the effect on public safety.

(q) That the City of Toronto request that the Government of Canada (Transport Canada) rationalize and amend the current list of DCs and SDCs.

(r) That Metropolitan Toronto, in cooperation with City authorities, prepare a plan for the safe operations of DC transport by truck in Toronto.

(s) That the City Department of Planning and Development investigate the impact of rail risk management measures on industries in Toronto.

(t) That the RTC investigate thoroughly whether any specific operating treatment for empty tank cars previously carrying DCs is justified in terms of operating and economic factors including public safety.

(u) That the City of Toronto request the RTC to assess the interrelationship of train length and the number of DC shipments present with specific attention to public safety.

(v) That the RTC ensure that rail operating data indicating changing traffic levels of categories of DC/SDCs in this area be provided to MTEPAC and the City of Toronto Fire Department on an annual basis for the use of emergency response personnel.

4. Recommendations to the Federal Task Force

We wish to make the following recommendations concerning the further analysis and deliberations of the Toronto Area Rail Transportation of Dangerous Goods Advisory Council.

(w) That a prime objective of the Task Force's research should be to establish a long-term or permanent solution concerning public exposure to rail transport of dangerous commodities, possibly in the form of a protected rail freight corridor. A protected corridor should be of suitable width and/or contour to protect adjacent communities from DC incidents.

(x) That the rerouting options described in Chapter 3 of this report be considered for possible intensive assessment.

(y) That the overall justification and necessity for a major rerouting option be determined. This would include, in addition to operational and capital financing, the economic costs of current DC traffic levels in terms of land development and public hazard impacts, plus impacts upon industry in Toronto.

(z) That bypass plans be assessed in relation to an overall rail risk management program in the Toronto CMA.

(aa) That the feasibility and impacts be assessed of a possible ban on through DC/SDC shipments by rail in the City of Toronto.

(bb) That the 25 mph speed limit be examined to determine whether it produces significant improvements in operational and public safety relative to the 35 and 50 mph limits now in force.

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INTRODUCTION

Our society depends upon an array of technological servants ranging from microwave ovens to computers. Possibly the oldest forms of technology are transportation land modes still based on the wheel. As these technologies advance, society resents and fights back at real and perceived incursions into other facets of our lives. We have had a love/hate relationship with the motor vehicle for some time now. The railway or 'iron horse' was originally a subject of awe and fear but in Canada became over the years the main symbol of Canada's growth into nation-hood and remains the revered senior-service among our wheeled servants. The largely rural society of its early days has today grown up around the rail lines in the form of the metropolitan centers and urbanized regions of modern Canada. Over the same time, the railways have turned to freight transportation and increasingly the freight has become synthetic chemicals and petroleum byproducts.

The two biggest media stories of 1986 have been of technological disasters, experienced by the two largest superpowers. These epitomized society's fear of runaway technology which increasingly has shown the potential for possibilities of large accidents threatening populations and environments.

As technology progresses, safety improves to levels our fathers could not have imagined. Nevertheless the public fears the big accident which makes headlines. A railway train represents the largest transport vehicle, other than the supertanker, an object of environmental not social fear.

The Mississauga accident of 1979 which evacuated thousands but caused no deaths, gave rise to a major retrofit of railway equipment as well as the current study and the Federal Task Force assignment designed to achieve a final resolution of this perceived community threat.

Terms of Reference

A major influence on the decision of the City of Toronto to review the subject of the rail transport of hazardous goods has been the findings of the Burton/Post study* released in May 1983.

This included two key recommendations which essentially proposed

1. Consideration, as a matter of urgency, of diverting the flow of special dangerous commodities from the Galt/North Toronto subdivisions of CP Rail to the York subdivision of the CNR.

2. That the possibility of railway relocation be considered as a permanent means of removing the transport of dangerous goods from the built-up areas.

On May 15, 1985 the RTC released its response to the Burton/Post report. This response rejected the first of the above recommendations that hazardous goods be diverted from the North Toronto and Galt subdivisions, primarily on the grounds that the need for such a step was not proven, and that the costs of such diversion would be excessive.

This RTC document also referred to the Railway Relocation and Crossing Act of the Federal Government. According to this Act, the RTC cannot take action on proposed railway line relocation or rail traffic rerouting without an application by either a provincial or municipal government.

In our judgment the City of Toronto decided to commission the present study both in response to the above actions of the CTC, and to the increasing public concern being expressed on this subject. A report

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* The Transport of Dangerous Commodities by Rail in the Toronto Census Metropolitan Area: A Preliminary Assessment of Risk, Ian Burton and Keith Post, Canadian Transport Commission, May 1983.

(October 15, 1985) from the Commissioner of Planning and Development of the City of Toronto to the City of Toronto Executive Committee outlined the terms of reference of an upcoming study of the Transportation of Dangerous Commodities by Rail. The following quotation from this report indicates the recommended scope of this work.

> "HAZARDOUS GOODS TRANSPORTATION BY RAIL IN TORONTO - STRATEGIC OVERVIEW
>
> Overall Objective. To assess the current and future status of the transport of hazardous goods by rail in the Toronto area with emphasis on safety consideration for the different community elements, and the implications of these for future initiatives and policies.
>
> Scope. For operational purposes the study will include the rail network for Metropolitan Toronto and environs (including the CN York Subdivision through Markham and Vaughan Townships).
>
> For land use impact and developmental considerations, the study would be confined to the City of Toronto.
>
> Study Program. It is proposed that this study be carried out in three stages:
>
> 1. An initial Review - a review of all available and pertinent reports, data, plans, policies, etc.
> 2. A Toronto Network Assessment - a determination of potential hazards and impacts across the system.
> 3. A Policy/Strategy Analysis - identification of key issues plus planning and evaluation of alternative measures leading to the development of recommended initiatives and policies."

Advisory Committee. This study was initiated by the Department of Planning and Development of the City of Toronto, and the consultant has reported to department staff. An Advisory Committee was formed, made up of the following government and railway officials.

Joint Chairmen

P.E. Wade, Consultant

R. Sasaki, Policy Planner, Department of Planning and Development, City of Toronto.

Members

R.H. Boehnke, Acting Manager, Environmental Health and Inspection Services, Eastern Health Area, Department of Public Health, City of Toronto.

J.E. Drew, Assistant General Superintendent, Transportation-Operations, Great Lake Region, CN Rail.

R. Gaade, Director, Planning and Research Division, Fire Department, City of Toronto.

J. Hendricks, Area Manager, Department of Buildings and Inspections, City of Toronto.

M.D. Lacombe, Regional Director - Ontario, Railway Transport Committee, Canadian Transport Commission.

Inspector T.J. Marchant, Coordinator, Metropolitan Toronto Emergency Planning Advisory Committee.

C,E. Minto, Superintendent, Toronto Division, CP Rail.

J.A. Pryer, Transportation Coordinator, Department of Public Works, City of Toronto.

N.P. Zucchet, Senior Planning Coordinator, Department of Public Works, City of Toronto.

This study, as a strategic overview, has covered a wide range of technical and administrative subject matter. Accordingly, the consultant, in his deliberations, was dependent upon a wide range of secondary sources and, in particular, upon the advice and resources of the members of the Advisory Committee. Accordingly, consulting staff have worked closely with the above Committee members who have provided important inputs to the study. Nevertheless they do not necessarily endorse the study findings and recommendations.

Study Scope

This report covers the study subject area in four subsequent chapters, each dealing with a specific study focus.

Chapter 1, 'A Growing Concern' provides background material including the definition and range of dangerous commodities, the evolution of this issue in Toronto, the record of rail accidents, and a description of the City's railway network.

Chapter 2, 'How Present a Danger?' addresses the nature and seriousness of rail accident potential in Toronto covering rail traffic levels, hazardous incident scenarios, hazard probabilities, and impacts and consequences related to different City districts.

Chapter 3, 'What Can be Done?' deals with the range of alleviation measures available. Some 33 measures are assessed in the categories of:

- operational safety,
- minimizing accident impacts,
- reducing population exposure to dangerous commodity transport.

Chapter 4, 'A Strategy for Toronto.' This chapter deals with the above subject matter in relation to the City's situation dealing with key issues, strategic options for the City, a proposed integrated safety program, and a list of 28 specific recommendations for action by the respective authorities.

CHAPTER 1

A GROWING CONCERN

1.1 - INTRODUCTION

Canada's economy relies on variety of chemicals. The controversy surrounding the rail transportation of Dangerous Commodities within the City of Toronto is but one aspect of the prevailing public ambivalence towards this condition.

Market demand for goods produced in whole or in part from Dangerous Commodities (DCs) shows no sign of slackening. Our demand for fuels, plastics, fertilizers, bacteria-free water, and a host of other goods is inextricably involved in our quest for improved 'quality of life.'

On the other hand, the public and the media have expressed substantial anxiety about environmental issues as diverse as acid rain, radioactivity, the 'greenhouse effect' and the effects of chemical spills. Whether or not this anxiety is based soundly in fact, it remains an important element in the controversy surrounding DC transportation, regardless of the mode employed.

Clearly, this dichotomy catches government, industry and the public on the horns of a dilemma of the 'you can't live with them, and you can't live without them' variety. Responsible and critical decision making is vital in this situation.

This chapter provides background information which will enable the uninitiated reader to understand the materials and issues discussed in later chapters. The first subject dealt with in this chapter is that of Dangerous Commodities--their control, their classification, and their characteristics.

Second, the history of the rail DC issue in Toronto and in Canada is presented through the findings of major research projects and public inquiries. This section is closely associated with Appendix B, which sets out the characteristics of tank cars and related safety measures.

Third, the accident record of the major Canadian railways is examined on an international, national and local scale. Emphasis is placed on examining the factors which affect the incidence of the various types of train accidents and events.

Finally, the development and nature of the rail system in the City of Toronto is examined, with specific reference to the characteristics of individual subdivisions and yards.

1.2 - WHAT IS A DANGEROUS COMMODITY?

1.2.1 - The Regulatory Definition

Essentially, a Dangerous Commodity is what common sense dictates--a substance which, when released from containment, can cause death or injury to humans, short-term or irreparable damage to the environment, or lead to property damage and evacuation. The actual working definitions applied by Environment Canada for the physical characteristics of each DC vary according to the general classes into which each falls. The United Nations system of a four-digit 'product identification number' is the listing accepted for use in Canada. This system comprises nine classes with a number of subsidiary divisions as follows:

Class	Commodity Type
1.1-1.5	Explosives (several types)
2.1	Compressed Gases - flammable
2.2	Compressed Gases - nonflammable
2.3	Compressed Gases - poisonous

2.4	Compressed Gases - corrosive
3.1	Flammable Liquids - flashpoint below -18 C
3.2	Flammable Liquids - flashpoint between -18 C and 23 C
3.3	Combustible Liquids - flashpoint over 23 C
4.1	Flammable Solids
4.2	Spontaneously combustible substances
4.3	Substances dangerous when wet
5.1	Oxidizers
5.2	Organic Peroxides
6.1	Poisons
6.2	Infectious Substances
7.0	Radioactive Materials
8.0	Corrosives
9.1	Miscellaneous dangerous substances
9.2	Environmental hazard
9.3	Dangerous waste.

A sketch of the characteristics of the substances in each of these classes can be found in section 1.2.3 below. The control of these substances is vested in the Federal Transportation of Dangerous Goods Act, 1985 (TDGA). This Act is administered by the Transportation of Dangerous Goods Directorate (TDGD). Though it is the highest administrative body, the TGDA delegates the authority for enforcement to a variety of bodies.

The Railway Transport Committee (RTC) of the Canadian Transport Commission (CTC) is responsible for the day-to-day enforcement of DC regulations as they apply to rail transport. Its chief regulatory instrument are the Regulations for the Transportation of Dangerous

Commodities by Rail, commonly called the Red Book. The Red Book was revised in February 1986 to ensure its compliance with TDGA.
The Red Book is periodically updated by the RTC to reflect changing practices in rail transportation, and to add or remove certain chemicals from the DC list. Approximately 2250 substances are classed as DCs in the Red Book.

Based on a recommendation from the recently commissioned Toronto Area Rail Transportation of Dangerous Goods Advisory Council, known as the 'Federal Task Force,' the RTC and the TDGD are in the process of setting up a formal schedule for future reviews of the Red Book to ensure it remains in accord with the TDGA.

The DC list contains a subset called the Special Dangerous Commodities (SDC) list. The SDCs are commodities whose properties are so serious that they could cause damage over a broad area if they were released. As a result, these commodities must be handled with the greatest caution. The Red Book lists 402 SDCs. If the category of explosives, many of which are automatically treated as SDCs, is excluded, 282 SDCs of various types remain. This latter number also includes several 'catch-all' 'not otherwise specified' categories to ensure nothing is missed.

The SDC classification has been subjected to some criticism. On the whole, SDCs are explosives, compressed gases, spontaneously combustible substances, poisons, or are radioactive. Only the strongest corrosives, oxidizers, and flammable liquids are classed as SDCs.

In the United States, the National Transportation Safety Board (NTSB) has challenged the lack of concern given to date to flammable liquids. These liquids, such as styrene and toluene, are among the most frequently transported DCs, and have a history of involvement in major accidents. Sulfuric acid does not have a history of exacerbating accident severity, but it is a frequently transported DCs and can cause severe, though very localized, damage. Nonetheless, both in the US and Canada, the chemical properties of these commodities are not sufficiently pronounced as to warrant classification within the bounds of the SDC.

The Canadian system, which emphasizes the use of strict definitions of chemical properties as required for inclusion in the DC or SDC lists, avoids some problems experienced in the US. The NTSB identified several circumstances where the boundaries of certain classes--in one case, poisonous compressed gases--were not adequately defined to reflect the hazards of particular chemicals. The institution of a review procedure between the RTC and TDGD is a step in the direction of ensuring such errors do not occur here.

The SDC listing has proven a very useful guide to those commodities which merit the closest attention. Its value can be further advanced by increased concordance between the TGDA and the controls imposed by regulatory agencies such as the RTC, and by ensuring that carefully designed scientific standards are used to classify additional commodities.

1.2.2 - What is Known About DCs?

It is said that over 300 new man-made chemicals are marketed each year Few of these undergo testing for human and environmental side effects, and most of those which do are pharmaceutical and pesticides.* Of course, few of the substances which are not tested are ever likely to be transported in tank car volumes.

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* Chant D. and R. Hall, 'Ecotoxicity in Canada,' in Probe Post, Pollution Probe, Toronto, Jan.-Feb. 1980.

1.2.3 - The Short-Term Danger of DC Releases

The hazards posed by the physical properties of DCs are of various types. Below is a breakdown of the general type of hazards and characteristic of each class of chemical in the UN listing. Included in each section are some examples of common substances in each class, with those which were transported through the City of Toronto in 1985 marked with a 'T'. For the purpose of illustration only, a number of examples of major North American accidents involving these classes of chemicals is also included. This list is highly selective, and should in no way be construed as denoting the relative frequency of accidents.

Class 1.0 - Explosives

These substances burn virtually instantly, releasing very large quantities of heat and gases. Intense blast waves are propagated, and debris is often thrown at high velocity. Explosives can, through improper handling or temperature control, become unstable and subject to unintentional ignition. Exposure to flame, corrosives, or electrical current is usually required for ignition.
Example: explosives seldom carried in the City of Toronto, military weapons, industrial explosives. Major accident: Benson, Arizona, 1973.

Class 2.1 - Flammable Compressed Gases

These gases are usually fossil fuel products. They are very flammable, vaporize powerfully at ambient pressure, and have wide ranges of flammability. These commodities are also among the most frequently transported DCs. A wide variety of accidents can result, from small torch fires to massive BLEVEs (Boiling Liquid Expanding Vapor Explosion, see page 82). Secondary fires often occur from the large size and force of fires involving these substances.

Example: Propane, butane, (LPG) (T), propylene (T), isobutylene (T), butadiene, vinyl chloride. Major accidents: Crescent City, Illinois, 1972; Mississauga, Ontario, 1979; MacGregor, Manitoba, 1980; Livingston, La., 1982; San Antonio, Texas, 1986.

Class 2.2 - Nonflammable, Compressed Gases

These gases pose none of the usual threats. Instead, they are intensely cold, and can cause frostbite from direct contact with liquid or fresh vapor. Vapors, though inert, may cause death or injury by asphyxiation, since they reduce the oxygen content of air. Oxygen, on the other hand, can exacerbate fires or chemical reactions in the accident area.

Example: Carbon dioxide, nitrogen, oxygen, argon, helium, neon. Major Accidents: None found on North American railways.

Class 2.3 - Poisonous Compressed Gases

These gases cause death or injury through direct attack on the nervous system, oxygen absorption in plants and animals, or other severe interference in life functions.

Example: Sulphur dioxide (T), phosgene, cyanogen. Major accidents: None found on record in North American railways.

Class 2.4 - Corrosive Compressed Gases

These gases are generally not flammable but can destroy or severely damage living tissue . Some of the gases like chlorine and the anhydrous acid gases, form strong acids when in contact with the moist tissue of the eyes or the respiratory system. The anhydrous acid gases have the particular hazard of being able to penetrate dry tissue walls such as the skin. Anhydrous ammonia, a base, destroys moist tissue through desiccation. These gases, with the exception of anhydrous ammonia, are generally denser than air and upon release form clouds, about 50 metres in height, which stay near the ground.

Example: Anhydrous Ammonia (T), chlorine (T), anhydrous hydrogen chloride, fluoride, bromide, and iodide. Major accidents: Pensacola, Florida, 1977; Youngstown, Florida, 1978; Crestview, Florida, 1979, Mississauga, Ontario, 1979.

Note: Canada is the only country in the world which distinguishes between poisonous and corrosive compressed gases. In other countries, the two categories are compounded.

Class 3.1 to 3.3 - Flammable and Combustible Liquids

These liquids are considered dangerous due to the combination of high rates of vapor production in air, ease of ignition, and high burning rates when ignited. Running pool fires are a possibility. The three divisions are distinguished by the flashpoint temperature at which vapors ignite. This characteristic is very important, because weather can significantly affect the potential for the ignition of spilled liquids. Most of the commonly transported flammable liquids fall in division 3.2. All flammable liquids can exacerbate accidents by propagating secondary fires or explosions in other DC cars and nearby objects.

Example: Styrene (T), toluene (T), gasoline (T), benzene (T), isopropanol (T), xylene (T). Major accidents: Mississauga, Ontario, 1979; Livingston, La., 1982; Marshville, North Carolina, 1984.

Class 4.1 to 4.3 - Flammable Solids

The hazards presented by this group are in three types. First, class 4.1 burn very intensely. Second, class 4.2 will ignite spontaneously in air. These substances are highly reactive and, on burning or reaction, produce clouds of corrosive oxide fumes. Third, class 4.3 are substances which emit flammable gases when wet. Only class 4.2 can pose a hazard on a wide geographic scale, but the other two may exacerbate fires and reactions, and can make fire-fighting very difficult.

Example: White or yellow phosphorus (T), calcium carbide, liquid or molten sulphur. Major accidents: Miamisburg, Indiana, 1986.

Class 5.1 to 5.2 - Oxidizers and Organic Peroxides

These chemicals are very reactive with other substances and readily decompose when in contact with organic substances. Reactions release a great deal of heat and may, under certain circumstances, be explosive. When heated, most oxidizers and organic peroxides become unstable and potentially explosive. Certain of these substances react violently, or even explode, when in contact with water. Corrosive oxide fumes are produced which can irritate or damage the eyes, mucous membranes, and skin. Most of these substances which are transported by rail are of a low order of reactivity or are inhibited. Their main hazard is their potential for contributing to the severity of other DC releases due to the intensification of fires and/or chemical reactions. These effects, on the whole, will affect only the immediate vicinity of the accident site.

Example: Hydrogen peroxide, perchloric acid, sodium chlorate. Major Accidents: None on record by rail in North America.

Class 6.0 - Poisonous and Infectious Substances

These can be liquids or solids and are very dangerous. Their predominant hazard is from inhalation of vapors, but toxic gas production through chemical reactions or fires is of concern. In some cases, the water used to extinguish fires may cause gas production. Release of liquids may lead to aquifer penetration. Solid or liquid release into streams may cause severe water contamination. Gas distribution in smoke from fires leads to downwind spread of dangerous fumes, sometimes without tangible warnings such as odors or colored fumes.

Example: Tetraethyl lead (T), perchlorethylene, some pesticides, most cyanide compounds such as calcium cyanide (T), phenol. Major accidents: Colonial Heights, Vg., 1982, Livingston, La., 1982.

Class 7.0 - Radioactive Materials

The radioactive materials transported by rail are usually in small volumes in pool car shipments. Usually they are radioactive at very low levels for use in medicine and research. Hazard from release of these substances is unclear, but would probably be restricted to the accident site.

Example: Yellowcake, Cobalt 60. Major accidents: no accidents with release or exposure to fire in North America. In the Thermal, California, 1982, accident class 7 materials were part of a derailed highway trailer on flat car shipment.

Class 8.0 - Corrosives

These substances are generally transported as liquids. Their hazards are of two main types. First is their direct exposures in dilute or concentrated forms to humans or the environment. Burns or death may occur. The greatest consequences would result from fume inhalation. Both fuming sulfuric acid (oleum) and nitric acid produce clouds of very corrosive fumes. Inhalation or exposure of tissue produces effects similar to those of corrosive compressed gases. Furthermore, acid fumes tend to be denser then air.

Finally, all acids are highly reactive with many substances, and can produce ignition of some materials.

Example: Fuming sulfuric acid (oleum) (T), sulfuric acid (T), caustic soda (T), nitric acid, hydrochloric acid, bromine. Major accidents: Denver, Colorado, 1983; Parry Sound, Ontario, 1986.

Class 9.0 - Miscellaneous Dangerous Substances
Class 9.2 - Environmental Hazard
Class 9.3 - Dangerous Waste

The wide variety of substances occurring in these groups makes generalization difficult. Class 9.1 encompasses all substances which either cannot be satisfactorily categorized or which have yet to be classified. Class 9.2 deals with those substances whose hazards are specifically related to the environment. Class 9.3 is seldom transported by rail but could be locally damaging if released.

Example: Asbestos, ammonia nitrate fertilizer. Major accidents: none on record in North America.

The types of events caused by release of the chemicals listed above are generally well documented and understood. The behavior of these substances in certain circumstances which may result from a major railway DC accident are not, however, so well understood.

Chief among all the unknowns in DC releases--particularly in the jumbled mass of shipments that typifies a serious railway accident--is the production of a "chemical soup." Current marshalling regulations are intended to minimize this affect. Nevertheless, most DCs are to some degree reactive. When mixed together in a situation of intense heating, the number of unusual compounds which can be formed is disturbing indeed. Certain commodities are more prone to this phenomenon than others. Chlorine is often singled out, as are pesticides, herbicides, and the numerous cyanide compounds.

The immediate hazard in such situations is that these compounds may be distributed by, and hidden in, the smoke and fires that often follow railway accidents. These combination effects are, first of all, a threat to emergency response personnel. The potential for downwind distribution of these substances may expose nearby population and the local environment.

It should also be very clearly understood that because a chemical is listed as a particular type of DC, as seen above, it does not mean that is the only type of hazard it possesses. The classes above were set out on the basis of the predominant or major effect of each chemical. In fact, most DCs can be hazardous in a variety of ways. Most are highly reactive with other compounds. Some are also strong oxidizers. Virtually all are poisonous if encountered in sufficient concentrations and by certain means of entry into the body. Propane, for instance, is predominantly a hazard due to its flammability but it can also asphyxiate in high concentrations. So, a DC when released cannot be assumed to have effects strictly limited to those expected of its DC class; it may have secondary effects which cross over into those of other classes.

1.2.4 - The Long-Term Dangers of DC Release

Railway transportation of DCs is sometimes accused of exposing nearby populations not only to the immediate hazards of DC release, but also to human and environmental damage which may not be manifested for months or years. This concern has, at first glance, the ring of common sense, but a closer examination reveals flaws in its assumptions.

The core of the matter lies in the difference between acute and chronic exposures. The insidious effects of mercury and 'agent orange' on humans have excited concern, but it must be noted that these effects are due to the chronic exposure of individuals, over a period of months or years, to concentrations of these substances.

The effects of acute exposure are of a very different order. Exposure to chemicals spilled in rail accidents is clearly evident due to the accident having occurred; there is no silent, hidden exposure to the substance. The duration of exposure is very short and, though concentrations may be high, they will also likely never be repeated.

This is not to minimize the potential effects of acute exposure; they can range from coughing, tearing eyes, and nausea up to burns, blisters, lung and liver damage, and even death. It is extremely unlikely, however, that such exposures will lead to later effects which can be directly or indirectly related to the initial exposure.

The very nature of railway accidents mitigates against chronic exposure. In the first place, the railways are required to report even small leaks; losses of large volumes of chemicals would certainly be known to all concerned. Furthermore, a train derailment or collision is a very noisy event, frequently accompanied by major fires. Emergency response teams are on the scene within minutes, and public safety is the chief concern. Furthermore, the law in Ontario now forcefully commands all spills be promptly and properly cleaned up. This clean-up process is usually underway within hours or days of the event.

In only one accident in the recent past has chronic exposure been a major concern. Several tank cars containing the potential carcinogen perchlorethylene were breached in the Livingston, Louisiana, accident. The substance was not involved in fire. It was feared that the substance might seep down to the aquifer, thus contaminating the ground water. Since many of the town's residents drew their water from wells, it was decided to remove 40 000 m^3 of soil to avoid the possibility that through chronic exposure via their drinking water, the residents might suffer long-term health effects.

The railways do carry substances which, if released in sufficient quantities and means, could lead to long-term effects on local populations. The fact of the matter is that these circumstances are very improbable, especially in dense urban areas. Part of the problem at Livingston stemmed from poor documentation of cargo but, as seen in Chapter 3, both CN and CP have many ways of swiftly communicating accurate train consist information to emergency response personnel. The nature of rail accidents strongly reduces the likelihood that long-term health damage would result.

1.3 - EVOLUTION OF THE DC ISSUE IN TORONTO

Before beginning this section of the report, the reader is strongly advised to read Appendix 2 in its entirety. This appendix explains the characteristics of tank cars, tank car safety measures, and trackside detection equipment in detail. The following discussion will be comprehended much more readily with a sound basis in technical matters.

1.3.1 - The Mississauga Incident

On the night of November 10, 1979, 24 cars of a CP freight train derailed at the Mavis Road crossing in Mississauga. One of the plain bearings on the rear truck of a tank car containing toluene overheated --'hot box'--and the wheel pair was lost. The derailed tank car was dragged along for some 3 km until, it stuck on a switch, thereby causing the derailment.

During the derailment, which took place at 50 mph, the toluene car ruptured, starting a very large pool fire. During the derailment, two propane tank cars of the DOT112J class were damaged and some portion of their insulation jacket was lost (Fire Command, 1980). As a result, they BLEVE'd (Boiling Liquid Expanding Vapor Explosion, see page 82) earlier than their designed minimum pool fire endurance. Several other tank cars of flammable liquids and compressed gas then became involved in fire.

No one knows whether it happened during the derailment itself or during the BLEVEs, but the sole DOT105 tank car involved in the derailment was breached. It contained highly dangerous chlorine gas which, being denser than air, flows in thick clouds along the ground. The intensity of the fires carried most of the chlorine gas aloft, where it dissipated harmlessly.

Unable to determine how much chlorine was left in the tank, emergency response officials began a series of 15 steadily expanding evacuations. At its height, 226 000 people were forced to leave their homes, some for more than a week.

The aftershocks of the Mississauga incident are, to an extent, still being felt today. The safety measures expedited or implemented after the accident have greatly improved railway safety. The public perception of DC transportation by rail has been deeply marked by this event. The Mississauga accident remains the signal event in the history of the DC issue in Toronto.

1.3.2 - The Grange Inquiry

Commissioned 24 days after the Mississauga accident, this Inquiry, headed by Justice S.G.M. Grange of the Supreme Court of Ontario, examined the causes and events of the incident, the actions of train crew and emergency response personnel, and the role of railway equipment in the accident.

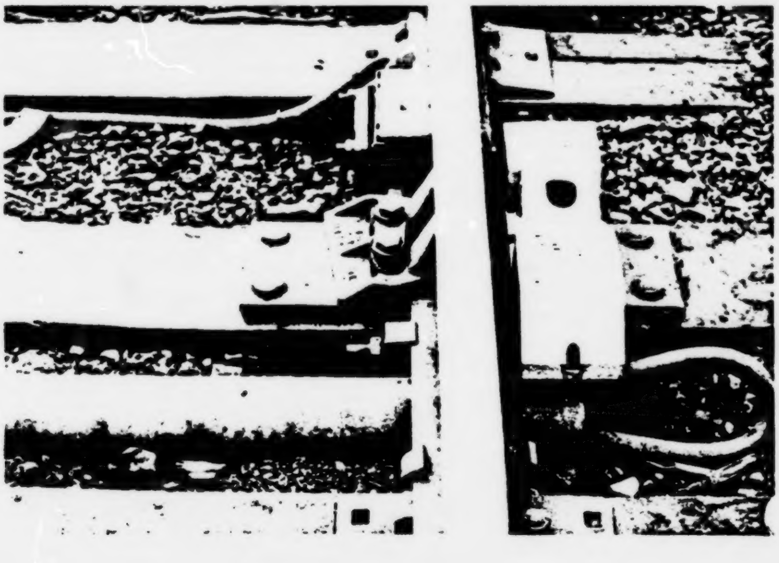
The Inquiry was not obligated to consider the economics of its recommendations, three of which caused controversy. These were as follows.

> Recommendation 1
>
> All trains carrying dangerous goods of any kind should be equipped as follows:
>
> (a) All cars whether dangerous goods cars or not should have roller bearings.
>
> (b) All tank cars should have double-shelf couplers.
>
> (c) All 112 and 114 tank cars should have head shields and thermal protection.
>
> (d) All 114 and 111 tank cars which have bottom fittings should have bottom fitting protection.
>
> Recommendation 2
>
> Subject to recommendation 3, the routes of any trains carrying dangerous goods through built-up areas should be protected by hot-box detectors. No point within the built-up area should be more than 20 miles from hot-box detector protection.
>
> Recommendation 3
>
> If a dangerous goods train does not comply with Recommendation #1, it should not exceed 4 000 ft in length regardless of the hot-box detector protection provided.
> If the dangerous goods train does not comply with Recommendation #1, or the route of the dangerous goods train passing through a built-up area does not comply with Recommendation #2, the train in passing through the built up area should not exceed 25 miles per hour.
>
> (Grange et al, 1980)

These were the most significant findings of the Inquiry, and were to be implemented immediately. The Railways had been retrofitting rolling stock with the safety features discussed in Recommendation #1, but were employing a long lead time for implementation.

Noteworthy among the other twelve recommendations were improved crew training and supervision, greater availability of accident data, and the establishment of a Canadian body analogous to the AAR.

The Journal. Object of great concern, the journal is seen projecting outwards from the wheel. In this case, the journal is supported by roller bearings. The legendary 'hot box' occurs when the bearings fail and the journal begins to overheat, fracture, or melt.



Hot Box Detector. Located outside each track, this infra-red monitor measures the temperature of each passing journal (axle end) and relays this data to the nearby computer.

Shopping Centre east of Newmarket subdivision at connection with Galt/Weston corridor showing overgrown, abandoned sidings.

Industry and high-rise housing abutting right-of-way on Galt/Weston corridor. Looking north at Dundas Street.

The significance of the Grange Inquiry to Canadian railway safety is great. The recommendations made by the Inquiry have set the tone for future safety measures and studies.

1.3.3 - The Show Cause Hearing

This was an opportunity given by the RTC to interested parties to 'show-cause' why the first three recommendations of the Grange Inquiry should, or should not, be implemented. The railways and various shippers opposed the immediate implementation of these measures as uneconomic and logistically infeasible.

Unlike the Grange Inquiry, the Show-Cause Hearing was very conscious of the need to evaluate the cost-effectiveness and practical implementation periods of the various safety measures under review. A major consideration regarding these measures was their effect on the competitive position of railways vis-a-vis other modes of transportation; implying that the existing balance between rail and other modes, and trucking in particular, should not be disturbed.

The Show-Cause Hearing decided as follows.

Finding No. 1 - Safety Measures

A. Roller Bearings

By December 31, 1987, all Canadian railways are to have 75% of their revenue car fleet so equipped. All newly acquired cars must be so equipped.

B. Double-Shelf Couplers

Canadian railways may not accept for transportation, unless so equipped:

- after June 30, 1982, any 105 tank car,
- after February 28, 1985, any 103 or 111 tank car used to carry DCs,
- after September 30, 1981, any newly built tank car of any class,
- (retrofits to all 112 and 114 tank cars were completed in March of 1979).

C. Head Shields

- Only full head shields may be used on new cars or in future retrofits, effective September 30, 1981.

- All 105 tank cars built after December 31, 1981, with the exception of those designed for operation at or above 500 psi, must have head shields equivalent to those of 112 and 114 cars.

- (All 112 and 114 cars had to be retrofitted with head shields by June 30, 1981.)

D. Thermal Protection

- All 112 and 114 cars not previously retrofitted must be so by December 31, 1982.

- All 105 cars built after December 31, 1981 must meet the same standards as 112 and 114 cars.

- (All 112 and 114 cars carrying flammable compressed gases had to be so equipped by June 30, 1981.)

E. Bottom Fitting Protection

All Canadian railways were required to submit retrofit plans for:

- all 103, 111, 114 cars equipped with bottom fittings, in use to ship SDCs, by February 1, 1982,
- all 103. 111, 114 cars equipped with bottom fittings, in use to ship DCs, by June 1, 1982.

Finding No. 2 - Hot-Box Detectors

All Canadian railways were required to accelerate and broaden their already existing programs for the inspection and monitoring of moving trains. Plans were to be submitted to the RTC by:

- December 31, 1981, for urban areas larger than 100 000 persons,
- October 1, 1984, for urban areas between 50 000 and 100 000 persons,
- October 1, 1987, for urban areas between 10 000 and 50 000 persons.

These plans were to show 'gateway inspection points' for trains carrying SDCs. Permissible inspections consisted of a manual inspection by certified personnel, or a pull-by over a hot-box and dragging equipment monitoring device.

The placement of these gateway inspection points depended on several defined limits. In CMA's, the RTC set out a geographic area called the 'Densely Populated Area' which represented the outer boundary of dense urban development within the boundaries of the CMA. Theoretically, the CMA and DPA boundaries could coincide, though often they did not. The DPA is the area, in essence, in which the consequences of an SDC could be pronounced.

The gateway inspection point had to be placed no more than 20 miles from the DPA boundary. The point at which the rail line crossed the DPA was called the 'speed change point.' Restrictions on inbound and originating train are somewhat different.

A. Trains Inbound to, or Passing Directly Through, the DPA

If a gateway inspection is completed:

- trains carrying SDCs must reduce speed at the speed change point to 35 mph,

- if the train then runs within the DPA, an 'interval inspection' similar to the gateway inspection must be carried out, at a maximum, every 20 miles that the SDC train runs within the DPA.

If a gateway inspection is completed, but no interval inspection is done:

- SDC train speed must be reduced to 15 mph after it runs, at a maximum, 20 miles within the DPA.

If no gateway inspection is performed:

- the SDC train may not exceed 15 mph after passing the speed change point.

B. Trains Originating at Yards Within the DPA

If a safety inspection is performed:

- if a safety inspection of the SDC train is carried out by a Certified Car Inspector prior to leaving the yard, the train may run at 35 mph until leaving the DPA. Interval inspections are not necessary.

If no safety inspection is performed:

- if the safety inspection is not performed, the SDC train may run at 35 mph for a maximum of 20 miles within the DPA,
- if an interval inspection is performed, at or before the 20-mile point, train speed may continue to be 35 mph, provided subsequent interval inspections are performed within the DPA,
- if no interval inspection is performed, train speed must be reduced to 15 mph after passing, at a maximum, the 20-mile point within the DPA.

Once the SDC train leaves the DPA, it is free to run at the maximum speed permitted in the timetable for that particular track section. Trains containing DCs or nonhazardous freight are restricted to a maximum of 50 mph within the DPA, and are not subject to interval inspection requirements, though these inspections may in fact be carried out.

Trackside detector sites are required only to consist of a hot-box detector and a dragging equipment detector. Most railways, and CN and CP in particular, have included hot wheel detectors in these sites. This has been done entirely of their own volition, and has never been required by the RTC. Hot wheel detectors are not yet found in all trackside detection sites in Canada, though they are provided in all CMAs and in most other urban areas.

The RTC must be informed immediately of any hot box, dragging equipment, or hot wheel detections. The detection and speed requirements for urban areas are slightly different from those of CMAs, but are not germane to the issue as it pertains to the City of Toronto.

Other matters relating to trackside detection equipment are discussed in Appendix B, part 6.

Finding No. 3 - Train Length and Speed

After available safety information was assessed, it was decided that no restrictions were to be imposed on train length. Trains carrying SDCs are limited to 35 mph in urban areas greater than 50 000 population as of September 30, 1981. This maximum speed is subject, in CMA's, to the condition set out in Finding No. 2, above. In areas of 50 000 to 10 000 persons, this 35 mph limit will apply as of October 1, 1987 (RTC, 1981).

The orders imposed by the RTC following the Show-Cause Hearing remain in force. It should be noted that the regulations do not require DOT 105 tank cars built before December 31, 1981 to have head shields or thermal protection, nor are DOT 103 or DOT 111 tank cars built prior to September 30, 1981, subject to these requirements.

By imposing these regulations, the RTC set the character of safety measures for DC transportation. Chapter 3 of this report looks at the way in which the railways have complied with these regulations.

1.3.4 - The Burton-Post Report

The Mississauga derailment not only sparked nationwide action on railway safety, local concern also led the RTC in 1982 to commission a study called The Transport of Dangerous Commodities by Rail in the Toronto Census Metropolitan Area: A Preliminary Assessment of Risk. Known commonly as the 'Burton-Post Report,' this study was intended to pave the way for further study at some time in the future.

In addition to surveying the literature on risk from DC accidents and describing railway traffic patterns and RTC safety regulations, the report also developed what was called the "Relative Risk Index." Intended only as a guide for future work, this index multiplied the population density in two zones, one of 250 metres radius and the other of 1 000 m, along each subdivision, by the mean monthly total of DC cars passing along it.

This methodology does exclude a wide variety of conditioning factors, but there is some question whether this would have greatly altered the rankings of subdivisions. Ranked as most risky were the CP North Toronto and Galt subdivisions.

Following this determination, the Burton-Post Report then went on to make two highly controversial recommendations.

> 1. That consideration be given to directing the flow of SDCs off the CP Galt and North Toronto subdivisions and rerouting them along the Halton and York subdivisions of CNR. Such rerouting will require the making of some new connections between CN and CP tracks. The feasibility of this matter should be examined as a matter of urgency by the CP and CNR.
>
> 2. The rerouting of SDCs would substantially reduce the present level of risk, but it is only a palliative and temporary measure. It is suggested that the interested parties initiate an examination of the possibility of railway relocation so that new routes may be provided to permit the transport of DCs around population centers.
>
> (Burton-Post, ix, 1983)

These recommendations have been hotly debated ever since.

In fact, the recommendations of the Burton-Post Report crystallized an issue which the Mississauga derailment began--the desirability of allowing the main line of a major railway to pass through a densely populated urban area and, conversely, the desirability of allowing dense population growth to occur along existing railway lines. Subsequent developments, this present study included, have focused predominantly on the three issues of the danger to populated areas of existing patterns of DC transport, the feasibility of rerouting, and the feasibility of relocation.

Politically, the battle lines were formed with various municipalities, government departments, citizen groups, industrial associations and railways standing up for particular policies and actions.

In 1985, the RTC, as the regulatory agency with the final say on the matter, following several years of study and consultation rejected the first recommendation of the Burton-Post Report. Consultation with local municipalities showed polarization between those who would receive the rerouting, and who therefore opposed it, and those who supported rerouting because it lowered their levels of risk in the constituencies.

In addition, the authors of the report had not been able to incorporate into the report new statistics on safety increases due to retrofits to railway plant and rolling stock. The cost of rerouting would be some $80 million, which in view of the other factors was held to be far too expensive for the small net reduction in risk to the population of the Toronto Region. (RTC, May 15, 1985, p. 4)

The Burton-Post recommendation for a feasibility study of complete relocation was relayed by the RTC to any interested provinces or municipalities. Under the Railway Relocation and Crossings Act, the RTC has jurisdiction to require routing of traffic or relocation of railway lines. It exercises such power, however, only after the 'appropriate application' is made by the province or municipality concerned. This application must include plans for the redevelopment of the railway right-of-way, as well as a satisfactory transportation plan 'within a defined area' (RTC May 15, 1985, p.4). The RTC must be satisfied that all laws and powers are properly processed and available to the province and municipality. The RTC must also be satisfied that 'the railway neither benefits nor loses financially from implementation of the plan' (ibid).

The upshot of this legislation is that interested provinces or municipalities must be the initiators of the planning process which must precede relocation.

1.3.5 - Recent Developments

The issue of DC transportation by rail continues to be contentious. Due largely to the pressure from citizen's groups such as M-TRAC, the problem of DC transportation through urban areas has been kept in the public eye. Faced with a number of serious rail accidents in Canada and growing public pressure, Metro Toronto initially and the City of Toronto recently have in turn been placing pressure on the Ministry of Transport to do something about the situation. The City of Toronto Council has requested the RTC impose speed reductions on rail traffic along the North Toronto subdivision. In July of 1986, Council affirmed that its desire was to have all traffic on the CP North Toronto subdivision relocated to a 'low density area,' on the grounds that evacuation would be extremely difficult should an accident occur in the City.

Partly in response to public pressure and wholly as voluntary gesture of good faith, CP has since lowered the speed of trains carrying SDCs to 25 mph along the North Toronto subdivision. CP Rail volunteered this slowdown as a temporary measure subject to further study and final recommendations by the Federal Task Force.

The most significant of the recent developments is the commissioning of the Toronto Area Rail Transportation of Dangerous Goods Advisory Council. (The Federal Task Force.) This is an ambitious project with a two-year mandate to examine all relevant aspects of the DC issue, including matters relating to the feasibility of rerouting DCs, relocation of rail corridors, and imposing greater operating requirements on DC movements on existing routes. These alternatives will be assessed in terms of economic costs and benefits, social and community impacts, influence on rail operations, and the reduction of risk.

This present study, as outlined in the introduction to the report, is intended in part to provide the City of Toronto with information useful for submission to the Task Force.

1.4 - THE ACCIDENT RECORD

1.4.1 - International

The accident record of Canadian railways compares very favorably with American systems. In terms of train accidents per million train-miles, Canadian Pacific had the best safety record of the 16 major Class I railways in North America three of the last five years, never falling below third. Canadian National did similarly well, placing among the top five on three occasions, never falling below sixth. This pattern of excellence in relation to other continental railways is long standing, and is by no means limited to the previous five years.

Much is often made of the seeming disparity between the safety record of North American railways in comparison to European systems. The RTC has made a preliminary attempt to analyze this disparity by developing dependable comparative measures. Several distorting factors interfere with this comparison. First, European railways are passenger-oriented. Some, like British Rail, earn more from passenger service than freight. Also, European trains are smaller, lighter, and carry cargoes over a generally shorter distance than do Canadian railways. Finally, the reportability requirements for accidents and DC incidents differ from those in Canada.

In terms of train accidents per million train miles from 1981 to 1983, CP--whose statistics alone were open to the necessary modifications to provide comparability--showed a rate of 8.40; compared to an average of 2.5 for all European railways. This figure, however, includes all train operations--both passenger and freight. If the accident rate is standardized on the basis of billions of gross ton-miles to reflect the amount of freight work done, CP shows a rate of 1.84, only 28% of the overall European average of 6.47.

While comparability of the performance of Canadian and European railways is not entirely clear, it is apparent that CN and CP are highly safety conscious and among the safest railways in the Western world.

1.4.2 - National

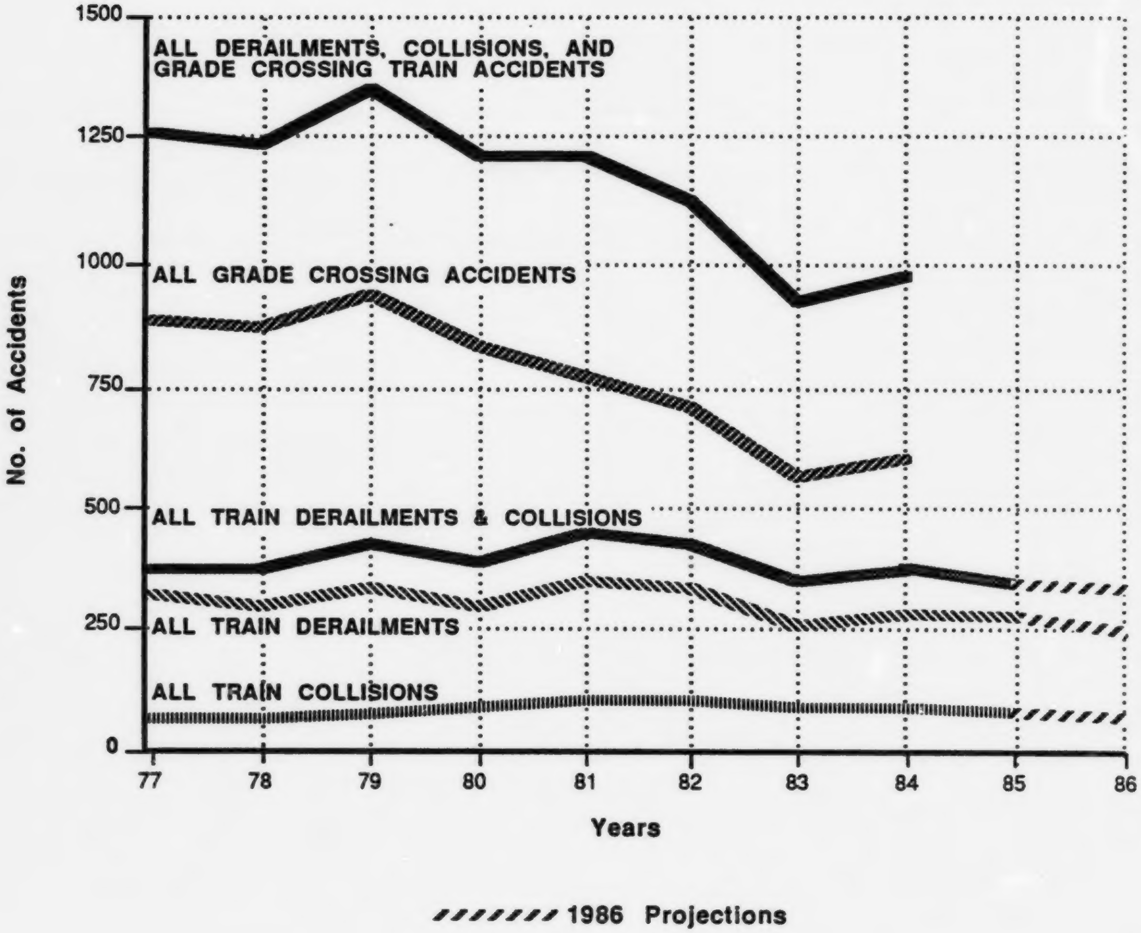
The occurrence of train accidents in Canada has shown substantial fluctuation over the last ten years. Figure 1.1 illustrates this variability. With the exception of the period 1979-82, it appears that the trend has been towards a decline in the frequency of train accidents. This decline is even more prominent when the effects of several distorting factors are considered.

The RTC defines a 'train accident' as:

> "An occurrence associated with the operation of a train, engine, car, track motor car, or other maintenance of way equipment involving property damage in excess of $750 for main line operations, and casualties or dangerous commodities

Figure 1.1

ALL TRAIN DERAILMENTS, COLLISIONS, AND GRADE CROSSING ACCIDENTS IN CANADA, 1977-1985, WITH A PROJECTION TO 1986



Note:

1 Projections to 1986 are the consultants

2 All Track Motor Car / Maintenance of Way Equipment accidents are excluded

Sources:

RTC, 1984, p12 (2.8)

RTC,1985, p7 (2.10)

in respect of both main line and yard operations in which:

- unit(s) of rolling stock derail (derailment)
- unit(s) of railway rolling stock collide with other unit(s) of railway rolling stock (collision) or with vehicular traffic at level crossings at grade (crossing accident)."

(RTC, 1985)

It should be noted concerning this definition that it was set out in 1975, when $750 was, in real terms, more than $750 is now. As a result, accidents are being reported now which might not have been considered reportable originally. This leads to a substantial overstatement of present accident frequencies. Also, the reportability requirements concerning DC cars in yard operations have recently been expanded to include 'empty' tank cars which last contained DCs, as well.

The railways are actively pressing the RTC to increase the minimum damage value from $750 to a figure in accord with the present American minimum of $4,500. This would serve both to remove the effect of inflation on the minimum reportability value and to allow direct comparison of Canadian and American accident rates.

Train accidents are of four types-- collisions, derailments, grade crossing, and track motor car/maintenance of way equipment. The latter is excluded from consideration in this report since they very seldom involve any DC, nor do they involve major costs or fatalities.

Grade crossing accidents account for the majority of train accidents and virtually all casualties in train accidents. Most of these events occur during the day and at protected crossings. This is largely owing to the higher volume of vehicular traffic on protected roads. The ratio of accidents where the train strikes a vehicle to those where the vehicle strikes a train is 3:2. DC involvement occurs in less than 2% of these accidents. Nevertheless, 58 people were killed nationwide in 1984 by crossing accidents.

Compared to the number of crossing accidents, collisions and derailments are relatively low in numbers. They are, however, the type of accident with the most frequent involvement of DCs and the greatest potential for damage. Derailments outnumber collisions, and are apparently much more subject to variation in their frequency of occurrence.

This relationship between derailments and collisions disguises the role of accident location in the general type of accident occurrence. Table 1.1 shows that derailment characterizes 'main line' accidents, whereas yard accidents are more likely to involve collision. An essential qualification should be noted: 'main line' denotes not only the heavily traveled lines running between major centers, but all switching tracks and industrial sidings stemming from the main lines. As is discussed in Section 1.4.3, this can have very important implications for the type and severity of main line accidents in urban areas.

The sole exception to the pattern of decline is yard derailments, which increased from 60 accidents in 1984 to 104 in 1985. The reason put forward by the RTC for this increase is that it is due entirely to the new reportability standards for 'empty'' tank cars which last contained DCs. (RTC, 1986).

The rapid drop in the number of main line derailments was noted by the RTC. After inquiry, it was determined that this decrease did occur,

TABLE 1.1

MAIN TRACK AND YARD DERAILMENTS AND COLLISIONS, CANADA 1981-1985, WITH A PROJECTION TO 1986

	All Derailments and Collisions Main Track & Yard	Derailments		Collisions		Main Track Derailments & Collisions	
		Main Track	Yard	Main Track	Yard	Per Million Train-Miles	Per Billion Gross Ton-Miles
1981	456	297	51	22	86	3.72	1.03
1982	428	273	54	26	75	4.05	1.08
1983	346	202	52	29	63	3.04	0.77
1984	375	213	60	17	85	2.77	0.70
1985	347	171	104	14	58	2.50*	0.62*
1986** Projected	328	160	105	22	41	n/a	n/a

---

* These figures are RTC estimates.

** These figures are the consultant's projections.

Source: RTC, Examination of Derailments and Collisions, 1985, p. 9.

and was not due to errors in data collection or collation. The RTC advanced no explanation, but CN considers it to have been due to the combination a number of factors such as track improvements, crew training, and maintenance.

Main track and yard accidents have very different implications for the likelihood of DC release. Though a variety of track types and train operations are subsumed in 'main track' one can generalize that the movement will be over a substantially longer distance than yard movements, speeds will also be higher, and that terrain may be irregular. Main track accidents, even though train movements are subject to central traffic control, are generally accepted as more likely than yard accidents to generate the severe dynamic conditions which may lead to DC release.

Yard accidents customarily involve lower speeds, fewer cars, and fewer commodity types. This generalization, it must be noted, may not always hold because yard conditions, though centrally controlled, are much more frequent and diverse than main track movements. As a result of this high level of internal activity, minor accidents are numerous. The dynamic conditions involved, however, are very low and seldom lead to DC release.

Table 1.1 also shows the overall rate of train derailments and collisions per million train miles on main track. It is noteworthy that the decline in accident frequency is consistent here, where train activity becomes a factor. The accident rate for billions of gross-ton miles is even more pertinent, since it relates these accidents directly to the amount of freight work done. Again, a marked decline after 1982 is evident.

Both Table 1.1 and Figure 1.1 show the projected main line and yard accident totals for 1986. Based on the first 80 days of 1986, it appears that a decrease can be anticipated in main line derailments, yard collisions, and total accidents; projected to be 183 as opposed to 185 in 1985 and an average of 215 per year over the previous five years. Yard derailments appear likely to remain consistent with 1985 figures. Main track collisions would appear likely to increase to 22, greater than the 14 which occurred in 1985. It should be noted, however, that in 1985 the same projection method used would have projected 22 collisions as well.

Projections are based on the assumption that the number of accidents per day in the first 80 days of 1986 would remain consistent throughout the year. This assumption appears to be conservative. The likely reason for this is that the first 80 days are the worst of the year for rail accidents. During this period track and equipment maintenance is very difficult, early thaws cause frost heave, and snow and rock slides occur in some areas.

Even if one calculates these projected figures on the basis of a 300-day working year, the projections still show a tendency when checked using 1985 figures to be lower than previously observed.

The significance of this is that it appears that 1986 will likely be one of the safest years on record, in terms of accident frequency. This contradicts the popular conception spawned by the tragic Hinton accident. Prior to this event, fatalities on Canadian railways were down to between three and one per year, and major injuries consistent between six and five per year. The casualty list from Hinton and the collision at Trudel, Quebec, will overwhelm this previous trend. Nonetheless, it may be that this year's tragic events, regardless of their specific causes, constitute relatively random disturbances in a general trend toward greater safety.

Major dangerous commodities accidents, those 'resulting in or having high potential for an explosion, fire, or evacuation', have over the last five years remained between three and five events per year (RTC, 1986). The low frequency of these events makes projections for the full year 1986 unwise.

DC events, defined by the RTC as any incident which does not arise from a train accident, occurred fairly frequently in 1984. There were a total of 419 such events that year, compared to 288 in 1983. This seemingly massive increase is due wholly to changes made to reportability requirements. Increased stringency leads to greater numbers.

Most DC events pose no threat to the public. Commonly, they involve leakage - usually drips and drops - from tank cars, containers, or accidentally damaged packages of pool car shipments. Railway DC-response staff are, according to standard procedure, always called in to ensure that the incident is correctly contained, halted, and cleaned up.

1.4.3 - Local

The geographic area considered as 'local' in this case includes an area bounded on the east by Pickering, to the north by Aurora, on the west by Burlington, and by Lake Ontario to the south.

During the three years 1983, 1984, and 1985, an average of 29 DC train accidents or DC events per year occurred on the CN system. The CP network saw only 12 per year. These figures are not related to train miles or other measures of the accident rate per unit of work done.

There were only two accidents during this period which definitely occurred in the City of Toronto. One was a derailment on the Toronto Harbour Commission tracks. The other was a derailment on the CN/CP interchange track where the CN Weston subdivision crosses the CP North Toronto subdivision. Both of these were minor accidents, occurring at very slow speeds, and no damage to the tank or release of DC occurred.

Table 1.2 shows a breakdown of the number, type, and general location of these occurrences on each railway. Several factors stand out.

First, the predominant DC event is the 'leaker'. These are tank cars or containers reported to be leaking their contents. Leakage generally results from improper sealing of valves after loading or from overfilling of the tank, which causes leakage when the tank is exposed to warmer temperatures or solar heating. Though the circumstances which lead to leakers are caused by negligence on the part of customers, once the railways accept transportation, they are responsible for the shipment. In fact, leakers are usually discovered by railway personnel during marshalling inspections.

Few leakers have the potential to cause serious problems. Leaks are generally in the form of slow drips, and seldom occur as continuous streams of fluid. in fact, many 'leakers' which are reported were not leaking at all. Spillage during loading or unloading can leave a distinct odor clinging to the tank car. Railway personnel often alert DC response staff on the basis of odor alone. Similar circumstances occasionally occur in container shipments. The hollow end posts of containers sometimes collect quantities of water from rain or condensation. When moved, the container may appear to be leaking as this water runs out. Nonetheless, railway DC response staff are always alerted. When leakage is occurring, these specialists generally correct the problem by tightening down or replacing valves, repairing the blocking and bracing in containers and pool cars, or by drawing off excess loads.

Leakers are primarily a yard phenomenon and, as is clear from the tables, constitute between 60 and 80 percent of all DC occurrences.

In terms of yard operations, it is noteworthy that all but three of the occurrences on CN trackage, and all but seven of those on CP, happened

TABLE 1.2

DANGEROUS COMMODITIES OCCURRENCES IN THE TORONTO REGION, 1983-1985

Type of Occurrence			Location of Occrrence	
Leaker	Derailments	Collisions	Subdivision	Yard
67	8	7		CN MacMillan
	2		CN Oakville - sidings	
		1	CN Kingston	
1				CN Mimico
		1		CN Brampton intermodal
68	10	9	= 87 Total CN Occurrences	
7		1		CP Agincourt
10	2			CP Obico intermodal
5	4	1		CP Lambton
	4		CP Mactier - siding	
	1		CP Toronto Harbour Commission - siding	
	1		CN/CP Interchange, CP North Toronto	
	1		CP Canpa - siding	
22	13	2	= 37 Total CP Occurrences	
90	23	11	= 124 Total CN/CP Occurrences	

Source: RTC, Examination of Derailments and Collisions, 1985, p.9 (2-11).

in yards. CN had an equal split between collisions and derailments, while CP had more derailments than collisions in yard operations.

DC events on subdivisions are quite rare, comprising two of CN's accidents, and six of CP's. Derailments were the predominant accident type on main lines. As was noted in Section 1.4.2, main track accidents also include those events which occurred on industrial sidings and switching tracks. The local data shows what is probably the rule in most urban areas. All but one of the derailments listed as 'main track' occurred on sidings and switching tracks. The sole main track derailment occurred on the Kingston subdivision.

The consistent thread in all these accidents and incidents is their minor nature. Most would have been static, or at very slow speeds. Few involved more than a couple of cars , and in no case was there a danger of a DC release occurring.

1.5 - INTRODUCTION TO THE TORONTO RAIL NETWORK

1.5.1 - Development

Railways have been an element of the urban fabric of Toronto since October 15, 1851, when construction began on the Ontario, Simcoe, and Huron Union Railway. From Front Street, just west of Simcoe Street, the line ran to Aurora, Barrie and Collingwood. This line is now the CN Newmarket subdivision.

From that beginning, other lines which help form the Toronto-centered regional rail network were laid out as follows:

1855 - Great Western Railway - now the CN Oakville subdivision.
1856 - Toronto and Guelph Railway - now the CN Weston subdivision.
1856 - Grand Trunk Railway - now the CN Kingston subdivision.

1871 - Toronto, Grey & Bruce Railway (acquired in 1884 by O&QR) - now the CP Mactier subdivision.

1874 - Credit Valley Railway (acquired in 1884 by O&QR) - now the CP Galt subdivision.

1882 - Ontario & Quebec Railway - now the CP North Toronto subdivision.

1887 - Ontario & Quebec Railway - now the CP Don Valley link.

1906 - Belt Line Railway - now part of the CN Bala subdivision and numerous industrial sidings.

1965 - CN York subdivision, Halton subdivision, and Macmillan Yard constructed to alleviate rail traffic congestion on the Lakeshore routes and provide a modern hump yard.

With the exception of the relatively new CN main lines, the addition of several new yards such as CP's Agincourt Yard, and the CP Canpa interchange, the railway corridors in the Toronto Region have been in place for nearly a century.

The corridors are the same, but the railway lines running thereon would certainly not be recognized by their original owners. Massive modernization programs have been undertaken over the years. Single tracks have become double or quadruple, rail has become heavier and heavier, streets have become grade-separated, stations rebuilt, and signalling is controlled by a centralized and computerized system. The CP North Toronto subdivision, for instance, is essentially a new railway, having been completely renovated and upgraded during the last two years. Figure 1.2 shows the present rail system in the City of Toronto.

As will be discussed in later sections of this report, the overall quality of rail plant, rolling stock, and traffic control has seen a manifold increase in the recent past. The railways plan more improvements and renovations, but the value and extent of these already completed is undeniable.

1.5.2 - The Rail System in Overview

This introductory chapter would be incomplete without a brief description of the characteristics of the various subdivisions and yards. Later sections of this report will deal with certain matters in greater detail, but this section sets the stage. The CN network will be presented first, then the CP, and lastly the TTR. Reference should be made to Figures 2.1 and 2.2 for information on the location and traffic volumes of the rail lines. In this description a through or symbol train is one which is either passing directly through Toronto to another city, or which is destined for or originating from a yard in the Toronto area. A transfer train operates between a main yard and a lesser yard to deliver cars to the lesser yard for subsequent delivery to customers by yard assignments.

Also for the purposes of this description, population within the High Consequence Zone (250 m radius, see Chapter 2) density is classed as 'high' if it exceeds 3.0 persons per meter of subdivision length, as 'moderate' if between 3.0 and 1.5 and 'low' if below 1.5 persons.

The CNR

The Bala Subdivision (Don Valley section, 1.95 miles within the City)

- This line is used by three transfer trains per day running from the Macmillan Yard to/from the Don Yard.
- One through freight train runs daily along this line.
- GO/VIA usage consists of 16 daily trains.
  Few industrial customers are serviced directly from this line.
- Population exposure is low.

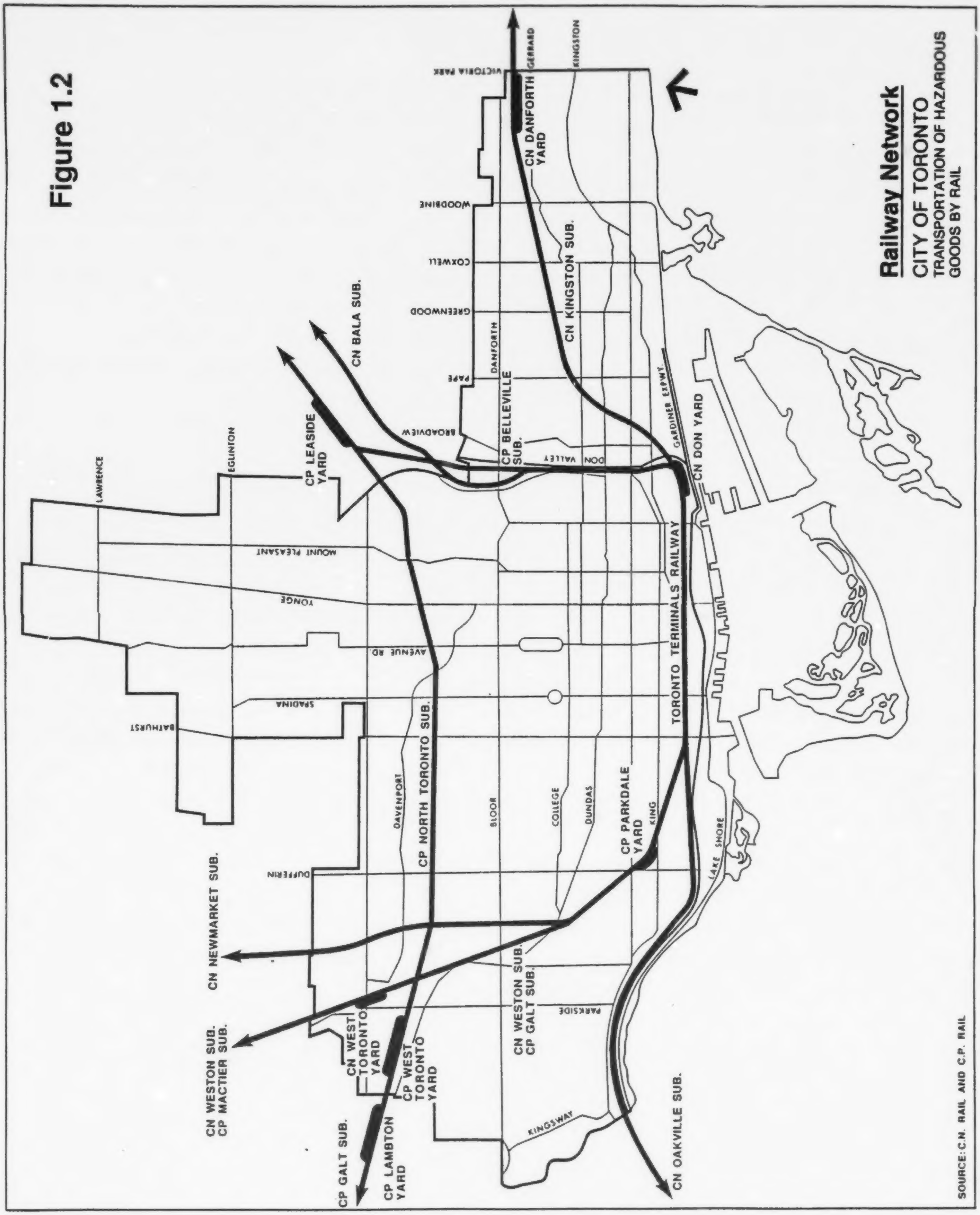

CN NEWMARKET SUB.
CN WESTON SUB.
CP MACTIER SUB.
CP GALT SUB.
CP LAMBTON YARD
CN WEST TORONTO YARD
CP WEST TORONTO YARD
CN WESTON SUB.
CP GALT SUB.
CN OAKVILLE SUB.
CP NORTH TORONTO SUB.
CP PARKDALE YARD
TORONTO TERMINALS RAILWAY
CN DON YARD
CP LEASIDE YARD
CP BELLEVILLE SUB.
CN BALA SUB.
CN KINGSTON SUB.
CN DANFORTH YARD
LAWRENCE
EGLINTON
MOUNT PLEASANT
YONGE
AVENUE RD
SPADINA
BATHURST
DAVENPORT
DUFFERIN
PARKSIDE
KINGSWAY
BLOOR
COLLEGE
DUNDAS
KING
LAKE SHORE
GARDINER EXPWY.
DON VALLEY
BROADVIEW
DANFORTH
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
GERRARD
KINGSTON

Figure 1.2

Railway Network

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

SOURCE: C.N. RAIL AND C.P. RAIL

The Kingston Subdivision (4.22 miles within the City)

- The major high-speed, high density eastward passenger corridor, carrying 80 GO/VIA trains daily.
- Through freight traffic is low at three daily trains, two of which are auto parts destined to/from Oshawa.
- DC volumes are low, and no SDCs are normally carried.
- Most freight activity involves the 4 transfer trains and 3 yard assignments operating out of the Don Yard.
- A number of industrial customers are serviced.
- Population density is moderate.

The Danforth Yard

- This yard is used primarily for storage of CN track maintenance equipment.
- Some tank cars which last contained DCs are occasionally left in this yard.

The Don Yard

- CN's main yard facility within the City, used both for storage and transshipment from CP to industries in the harbor area.
- Nine daily yard switching assignments, two daily originating/terminating transfer trains.
- Switching zone extends from the West Toronto Yard to the Scarborough Yard.

The Oakville Subdivision (Bathurst St.-City Limits, 3.94 miles within the City)

- The major high-speed, high-density westward passenger route, carrying 162 GO/VIA trains daily.

- Through freight traffic is low, at only two per day, both of which are auto parts train destined to/from Oshawa.
- Transfer train activity is low at 4 daily and 5 yard assignments.
- Some City of Toronto industrial customers.
- DC and SDC volumes are low.
- Population exposure is low.

The Newmarket Subdivision (3.26 miles within the City)

- This line is very minor, carrying little freight of any type and few DCs or SDCs within the City.
- Most train movements within the City are transfers to local customers or the Don Yard.
- No through freight trains operate on this line.
- GO/VIA usage is low at four trains daily.
- Population density is moderate.

The Weston Subdivision (4.81 miles within the City)

- This line is used solely to transfer freight to customers and to the Don Yard, no through freight trains operate.
- GO/VIA usage is moderate, at 18 trains daily.
- Interchanges with CP are provided at the CN West Toronto Yard, the CP Parkdale Yard, and Bathurst Street. The latter two interchanges are now inactive. The yards remain in use.
- DC and SDC volumes are low.
- Population density is moderate.

The West Toronto Yard

- This is a very minor element in the CN network.
- Transfer trains drop off cars which are then delivered locally by switching engines dispatched from the Don Yard.
- CN customers serviced from this yard are few.

Freight activity on the CN network within the City of Toronto is on the whole devoted to the reception and delivery of cars coming from the Macmillan Yard in York Region. The last vestiges of the old CN lakeshore main freight line are the daily auto parts trains running via the Oakville and Kingston subdivisions to and from Oshawa and Scarborough Yard. Most other through freight movements are routed along the York and Halton subdivisions, in and out of the main Macmillan Yard.

In general, the predominant use of the CN subdivisions within the City is high-speed passenger movement. This is especially true of the Kingston and Oakville lines.

The Don Yard is the only CN yard facility of any significance in the City. Its main function is to handle deliveries to and shipments from customers on the CN trackage in the harbour industrial area, and to receive and deliver traffic interchanged with CP at Cherry Street. The yard also handles the traffic to and from the Scarborough and Warden Avenue industrial areas which is set off or lifted by mainline through trains or by transfer train movements. Delivery functions from the yard cover a large area, and account for most of CN's customers in the City.

The CPR

The Belleville Subdivision (Don Branch, 1.91 miles within the City)

- This line serves solely to transfer shipments destined for or from CP customers to the CN/CP interchange at Cherry Street (Don Yard).
- No through trains are run, and only three transfer trains per day, which seldom run the entire subdivision length, concentrating instead in the area north of the Don Yard.
- DC volumes are low, and SDC volumes almost nonexistent.
- Population exposure is low.

The Galt Subdivision -
West Toronto Diamond to Union Station (3.85 miles within the City)

- This line is used partly for transfers to CP customers in the Toronto Harbour Commission sidings or the Cherry Street Interchange with CN.
- Renovations to the Parkdale Yard will increase subdivision's role as a transfer route.
- No through freights now run along this line.
- Transfer train volumes are low, at 6 daily.
- DC and SDC volumes are low, though this may be subject to change.
- Population density is moderate.

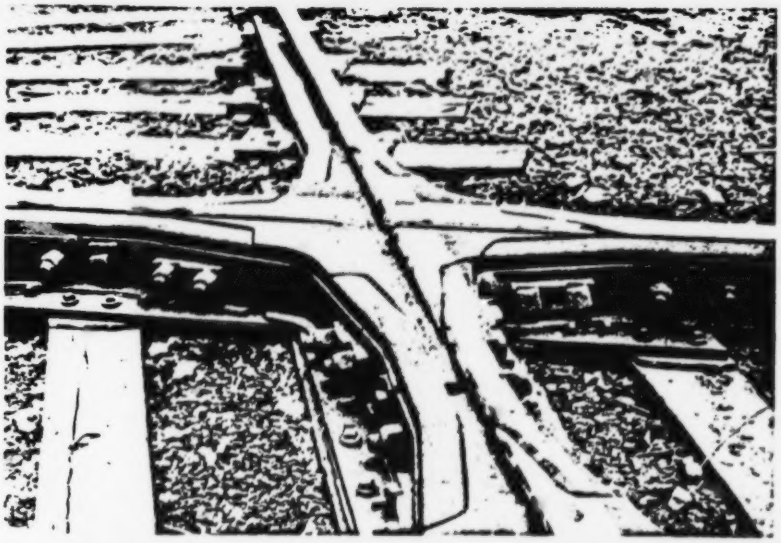
The Galt Subdivision -
Lambton Yard to West Toronto Diamond (1.22 miles within the City)

- This short stretch of track is very heavily traveled, including both trains destined for Agincourt Yard and those heading north on the Mactier subdivision.
- DC and SDC volumes are high.
- The acid unit train traverses this section of line.
- Population density is moderate, though much of the land near the line is in industrial use.

The Lambton Yard Complex

The West Toronto Yard

- This yard is passive, and is used largely for the storage of inactive and empty cars.
- Under special RTC permit, one track is designated for short-term(i.e. weekend) storage of loaded DC and SDC cars.
- This yard is an extension of the Lambton Yard.



Close-up. The Heart of the Rail Junction

Each control element is a single block of steel, cast individually, and costing $500,000. Inspection and management of these keystones of the rail system is frequent.

The West Toronto Diamond

The junction of several CN and CP subdivisions, this intersection is one of the most improtant track features in Metro Toronto.

High-rise housing, playground and illicit pedestrian crossing--Galt/Weston corridor, west side near Lansdowne Avenue.

Single-family houses backing on the Galt/Weston corridor near Shirley Street (east side).

The Lambton Yard

- This major CP yard facility just contacts the City boundary.
- Active marshalling of local trains, plus lifting and setting off of cars from/for through freight trains, and transfers to some customers west of Yonge Street occur in this yard.
- Shipments of DCs are sometimes set off at this yard.

The Mactier Subdivision (.96 miles within the City)

- A moderately active line, this subdivision handles all trains heading to northern Ontario or western Canada.
- Some trains lift shipments at the Ray Yard in York.
- DC and SDC volumes are much higher northbound. This is in part due to the unit acid train on deliveries to other municipalities north of Toronto.
- DC and SDC volumes are moderate.
- Population exposure is moderate, though a portion of its route in the City is in industrial areas.

The Parkdale Yard

- This yard is presently undergoing conversion to an intermodal yard specifically designed to handle all the CAST system's Toronto business.

The North Toronto Subdivision (4.8 miles within the City)

- This is the CP main line and provides through and transfer trains with a connection between the Lambton and Agincourt yards.
- This line has no customers or sidings along its length.
- Traffic volumes, DC volumes, and SDC volumes are high.

- Some double-shipping occurs after through trains headed to Agincourt are remarshalled there and cars are subsequently transferred westward to customers.
- Two through trains are designated to carry DC and SDC cars over this subdivision.
- Population density is moderate.

Unlike the CN network, the CP system is used predominantly for freight traffic. This is entirely due to the fact that the Galt-North Toronto subdivisions are the CP main line. As a result, traffic in general plus DC and SDC carload traffic is higher than for other lines in Toronto.

Most of CP's delivery transfers, however, do not occur in the City, but rather in Etobicoke, Mississauga, and Scarborough. Yard activity at Lambton does have an effect on the City in that the cutting of local DC consignments at this point prevents them being double-shipped through the City; first to Agincourt, then back to western customers. Some of this double-shipping does occur, but it is intentionally kept to a minimum. Most DC shipments on the North Toronto subdivision are going straight through to customers, and as a result provide a single exposure only to nearby residents.

The TTR

The Toronto Terminals Railway was created to give unified control over an area in which several railways are operating. The precise boundary of the TTR varies for each subdivision, but it can be generally thought of as starting at Bathurst Street and extending to the CN Don Yard.
CN retained a double-track bypass route, called the 'High Line' which runs along the south edge of the Railway Lands. This line is used for CN freight shipments through the TTR zone. Entry to and exit from the High Line is under TTR control.

Freight traffic through the TTR is low. CN runs three through freights, two of which are auto parts and vehicles trains running to/from Oshawa and the Scarborough Yard. Six CN transfers use this route, four operating to/from Mimico Yard, two to/from the West Toronto Yard.

It is this function of linking the eastern and western elements of CN's traffic in the southern portions of Metro Toronto and the lakeshore that makes the TTR more significant than its freight totals suggest. CN has expressed concern that loss of the TTR would greatly reduce the flexibility of their system to handle overflows caused by regular maintenance of the York-Halton subdivisions or by emergencies involving or affecting them. CP's traffic data in the TTR is not yet available.

The future of freight movement through the TTR is unclear given the impending urban development of the Railway Lands. Present proposals call for the High Line to be relocated much nearer, though still bypassing, Union Station. Before the CN freight bypass was built, the High Line was very busy. It is now a minor freight route, but it does perform functions which the railways presently consider essential.

As the Toronto Region continues to develop, it is very likely that the TTR will become more and more a focus of passenger traffic.

CHAPTER 2

HOW PRESENT A DANGER?

The current study is intended to appraise the nature and extent of hazard to the City of rail transportation of certain goods. This, in turn, can be the basis for future public decisions regarding necessary measures for alleviating potentially dangerous conditions. The process faced by the authorities is essentially one of trading off public perceptions of rail safety against the operating efficiency of the railway industry. The railway companies believe that they have achieved high levels of rail operating safety, while public groups perceive these operations as threatening the community with catastrophic accidents involving chemical spills. The current study is intended to examine the reality of rail safety levels in Toronto.

Society at both the personal and community levels continually makes judgments and chooses actions on the basis of perceived risks. The individual, on the one hand, apparently downgrades the risks of activities voluntarily undertaken--i.e. smoking, auto driving, skiing, flying, etc, while overestimating the risk levels of those conditions superimposed externally without citizen approval--for example, nuclear energy or weapons, acid rain, industrial pollution, and rail corridors in urban areas.

At the community level, society acts with greater rationality than individuals and responses to apparent levels of risk. Publicly funded programs exist to minimize the dangers of automotive traffic, fire hazards and criminal action, for example. At a lower level of risk, communities and families encourage safe behavior without incurring heavy public expenditure; for example: lifeguards, sanitation, anti-smoking warnings, etc. At even lower levels very little action is taken. Table 2.1 depicts actual levels of public risk. These are measured in terms of one person threatened per number of population at large.

TABLE 2.1

INDIVIDUAL RISK OF DEATH FROM VARIOUS ACCIDENTS AND NATURAL DISASTERS (U.S.)

Accident Type	Total Fatalities US	Individual Risk/Year
All accidents	115 821	1 in 2 000
Motor vehicles accidents	55 511	1 in 4 000
All industrial accidents	14 100	1 in 6 000
Falls	16 506	1 in 13 300
Drowning	7 152	1 in 29 000
Fires	6 503	1 in 32 000
Poisoning	5 335	1 in 40 000
Airplane crashed	1 668	1 in 130 000
Railway accidents (all railway accidents)	789	1 in 250 000
Lightning	160	1 in 1 300 000
Tornadoes	90	1 in 2 300 000
Dam failures	35	1 in 5 700 000
Gasoline tank truck accidents	28	1 in 7 400 000
Propane transportation accidents	15	1 in 15 000 000
Chlorine rail car accidents	9.4	1 in 22 300 000
Air crashes (persons on ground)	6	1 in 33 000 000

Source: Andrew, W.B. Pacific Northwest Laboratory 1980.
Various dates for fatality estimates 1980-1985.

In the case of industrial hazards, individual members of the public perceive high danger levels, while public authorities recognize the need to preserve industrial production and employment, and find themselves trying to balance public demands and industrial requirements. Policy positions resulting from this dichotomy range:

- from the goal of achieving the highest levels of safety possible,
- to a goal intended to achieve a balance between satisfying both public protection needs and industrial efficiency and competitiveness--a form of no-lose approach.

Examples can be seen in industries other than transportation. In the electric power industry different policies are pursued in the US and Canada respectively. Possibly as a result of lack of public confidence in private power operations in the US, adherence to a policy of maximizing safety at all costs has resulted in a limited approval of nuclear energy sites. Conversely, perhaps as a result of greater public confidence in publicly-run power systems, the use of nuclear power in Canada is more widespread; a decision apparently more rationally related to hazard levels (i.e. in the US the alternative to nuclear power has been coal-fired plants, a system with a greater level of probable public health hazard).

The case of rail transport has its unique strategic parameters. Rail transport is long-standing and well-established in urban areas and cannot be eliminated without important losses to the municipal economy. Furthermore, as with the power case discussed above, the modal options available can present higher risk levels to the community. In cases of a clear cut transfer of traffic from rail to truck traffic, there is no doubt that truck traffic has higher accident probabilities, operates in greater proximity to neighborhoods, and is less subject to safety controls than the rail mode.

As documentation of this advantage to rail, the following sources are quoted.

(i) Burton/Post, 1983, page 9:

> "In the case of propane transport, for example, it is estimated that the number of fatalities caused by transporting propane by road and rail in 1985 will be 15. This represents an individual risk of death to each person in the United States of 1 in 15 million per year. Of the expected fatalities only 0.5 (equivalent to one fatality every 2 years) stems from the movement of propane in rail tank cars."*

(ii) Canadian Transport Commission, Transport Review, 1985:

The following statistics reflect totals covering the period 1981 to 1983 inclusive in Canada.

	Rail (%)	Truck (%)
Percent total freight tonnage, all commodities	38	16
Percent of all fatalities and injuries	6.6	68.4
Percent of DC related fatalities and injuries	8	60

The above figures represent an advantage in relation to proportion of total freight tonnage of 21 to 1 for all fatalities and injuries and 18 to 1 for DC related fatalities and injuries. Over the three-year period there were for rail no fatalities and 10 injuries, and for truck 12 fatalities and 92 injuries.

In the option case where the hazardous traffic remains on rail but is removed from exposure to large segments of the urban public, the strategic parameters are quite different. The case of traffic diversion is likely the key question for authorities facing the subject of community hazards of rail transport. That is, are present hazards in Toronto, associated with the rail transport of hazardous goods, sufficiently threatening to justify the high levels of expenditure for diverting hazardous rail traffic?

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* Geffen, C.A. et al, 1980, An Assessment of the Risk of Transporting Propane by Truck and Train PNL - 3308. Pacific Northwest Laboratory, Richland, Washington.

The unique feature of rail traffic affecting the public controversy concerning its safety conditions in built-up areas is the size of the trains travelling along these corridors--the average number of cars per freight train travelling in Toronto is about 16 for the CN and about 49 for the CP, with train lengths at times exceeding 100 cars. Such trains, including locomotives, represent a mass of up to 5000 tons. When traveling at 50 miles per hour (as some freight trains are allowed within Toronto) a derailment or collision between trains can produce enormous destruction and equipment entanglement. In the case of narrow rights-of-way, overpasses and underpasses and population concentrations, such accidents can have potential for hazard and destruction.

In the following section, the attempt is made to present a descriptive picture of both the probability and consequences of rail accidents involving hazardous goods in the Toronto area. It should be noted that the consequences of rail accidents are not totally caused by hazardous goods involvement but can result from the accidental impact of non-DC traffic. Non-dangerous commodity freight cars represent, in the case of an accident, potential for both physical impact and interaction with dangerous commodities. Accordingly, this non-chemical component can enlarge and aggravate the extent of a rail accident's effect on a community.

2.1 - APPROACH TO HAZARD ANALYSIS IN OTHER CENTRES

Recent developments in Vancouver and Calgary in dealing with rail transport of dangerous commodities are discussed below in order to put the current Toronto situation in perspective. These outline different responses and analysis strategies to this area of municipal transportation. As well, the approach followed in the Burton/Post and Brad May (reference page 52) reports to conditions in Toronto are described. Finally, the sequence and analytic procedure followed in the current study are outlined.

2.1.1 - Vancouver and Calgary

In many respects the content and results of these two undertakings were diametrically opposite. In Vancouver's case the main public concern was the flow of dangerous commodities by road and rail through the CP slips in the Vancouver harborfront. In most cases these were flat loaded onto rail ferries. These transfers occurred in the heart of central Vancouver creating public fears of chemical disaster in the densest district of the Vancouver downtown.

The regional RTC office prepared an overview report in May 1982 (the Eisler Report) which made no attempt to estimate probabilities, consequences, etc, but on the basis of the amount of dangerous commodities handled and the obvious dangers of the operation, the following conclusions were reached:

> "The consensus of local opinion is now no longer a question of WHETHER the movement of dangerous goods through the downtown area should be prohibited but rather WHEN such prohibition should be arranged. The feeling is that it does not appear reasonable to expose such large numbers of people to potential difficulties even if the probability of an accident is low. Should an accident occur, there is a possibility that many people could be placed in jeopardy.
>
> The rerouting of that portion of the CP Rail traffic which is considered to be hazardous represents about 20% of the total volume moving through their ferry facilities, and at first glance it would appear to be a relatively simple matter to isolate these materials for shipment via other facilities... ."

Following a period of public hearings, the RTC prepared a Decision report in September 1985, laying down a program of rerouting CP Rail DC traffic by means of facilities other than the Vancouver harborfront.

Calgary is served by an extensive rail network of mainline, switching lines, yards, and industrial spurs throughout the City. It would appear that a general concern has existed in the City about potential rail hazards without focusing on a specific hazard location or issue. In 1982 a review of network hazards and feasible alternatives was carried out by a consultant. The main focus of this analysis was on the calculation of risk factors for different network elements and proposed alternatives. A risk factor was defined as the probability of an accidental death. A threshold level of one in 200 000 was defined as a level of public acceptance for dangerous commodity hazards. Hazards above this level would be considered unacceptable, justifying a review of alleviation measures.

Accordingly rail system improvements were considered (e.g. level crossing eliminations, rerouting of DC traffic, etc) and the degree of reduction in the risk factor was computed. (For example, in one case the risk factor was estimated to decrease from 0.000018 to 0.0000135 as a result of a proposed expenditure of $20 000 000).

Such data was overly abstract and difficult to relate to citizens' daily lives. A statistic quoted in the Calgary report was that rail accidents of all types were forecast to cause one death in ten years while motor vehicle accidental deaths were forecast at 880 in the same period. On the basis of these low forecasts the authorities in Calgary decided that the estimated improvement expenditures were not justified and that further investigations should be suspended. This focus on a single probability factor provided an abstract and obscure picture of the hazard arising from rail traffic, demonstrating little evidence of the various consequences of chemical spills from railway accidents, which, however improbable, might have to be faced.

2.1.2 - Toronto Reports

Two fairly recent reports on rail hazards in the Toronto area provided a different concept of risks concerning the rail transport of dangerous commodities in an urban area. These reports, previously cited, are:

- The Transport of Dangerous Commodities by Rail in the Toronto Census Metropolitan Area: A Preliminary Assessment of Risk, Ian Burton, Keith Post, for the Canadian Transport Commission, May 1983.
- The Rail Transport of Dangerous Commodities in the Toronto Census Metropolitan Area: Further Study on the Assessment and Management of Risk, Bradley K. May, Master's Dissertation, University of Toronto, 1984.

These two studies attempted to define hazard in terms of the exposure of population to dangerous commodities being transported, without statistical estimates of specific risk levels across the rail system. Each study had its own version of the risk index, in effect using a measure of public exposure as surrogate for formal probability estimates. This provides an indicator of aggregate effect (traffic frequency times audience) which can be useful for improvement priorizing but does not describe the severity of possible occurrences.

Burton/Post Report. Two inner and outer risk zones were defined--an Inner Risk Zone 250 m wide on each side of the tracks to cover the extent of short range events, and Outer Risk Zone of one kilometre on each side of the track, to cover the extent of major impacts.

In the thesis prepared by Brad May, a University of Toronto graduate student, the above formula was revised by adding the length of section to produce carload miles in place of carload volumes only. The use of carload miles is included in order to provide a surrogate value for accident probability. This report also analyzed other relevant parameters in an effort to assess relative risk potential along the routes.

2.1.3 - Comments

Following the experience of the above reports. the current study has avoided the Calgary approach of dependence on fatality probability for a number of reasons

- lack of confidence in fatality forecasting reliability,

- inappropriateness of a single parameter as an indication of accident impact, since other consequences besides deaths are involved, i.e. injuries, property damage, long-term environmental effects, etc

- it provides a too-limited strategic perspective of the subject. That is, a final resolution of network operational problems requires the consideration of various factors.

At the same time, we feel some estimate of probability is called for since the likelihood of accident is obviously a necessary consideration. The Risk Index approach used by Burton/Post and May has the merit of assessing hazard exposure as a reflection of relative risk conditions in Toronto. Nevertheless it is felt that the use of Index numbers is a generalization which masks the effect of important parameters (i.e. specific community and terrain conditions and rail operating features). Taking advantage of the above experience, the hazard analysis procedure has included the following elements:

- a spatially-oriented examination of each section of track in relation to the relevant transportation service, demographic, and physical parameters,

- an identification of the most significant hazard incidents and their broad probability, associated hazard zone, and severity of impact,- an assessment of these in terms of their likely consequences in relation to the various rail corridor neighborhoods and zones in Toronto.

The findings of these study components are discussed later in Section 2.7.

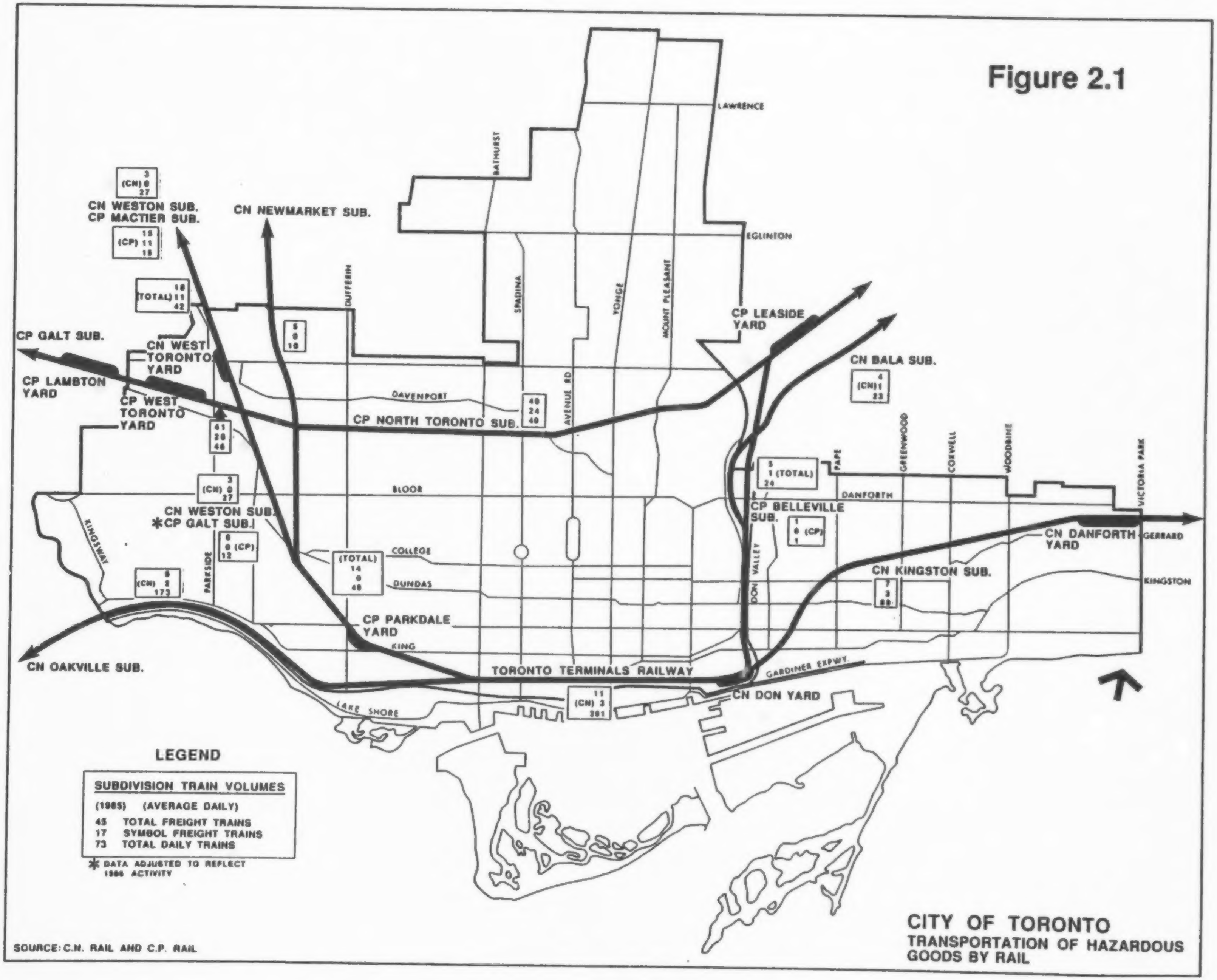
2.2 - RAIL TRAFFIC LEVELS

Figure 2.1 shows the box pattern of the railway network in the City of Toronto. These represent the original east-west main lines of the CP and CN plus the north-south connections for both railroads in the east up the Don Valley, and in the west up the Dundas/Weston Road corridor.

Figure 2.1 indicates the daily train traffic on the respective rail subdivisions in the City of Toronto. This exhibit reflects the specialization of the east-west CN and CP lines, whereby the northerly CP North Toronto subdivision is totally committed to freight movements, while the CN Lakeshore line carries predominantly passenger traffic with 97% of west-bound trains on the Oakville Sub and 92% of east-bound trains on the Kingston Sub made up of the GO Transit and VIA Rail passenger services.

Figure 2.1 shows the number of symbol trains on each rail section. These consist of long-distance trains operating into and out of Toronto on a regular schedule. The combined north-westerly corridor (consisting of the CN Weston Sub and the CP Galt Sub) carries no symbol trains out of a total of nine freight trains. Figure 2.2 shows a total of 75 200 cars of freight shipments traveling on this rail link during the last half of 1985. A large proportion of this will be local movements carried on transfer and switching trains. On the other hand, Figure 2.1 shows that 60% of trains on the North Toronto Sub are symbol trains, with the result that most of the 343 000 freight cars on this link (see Figure 2.2) will be long-distance traffic.

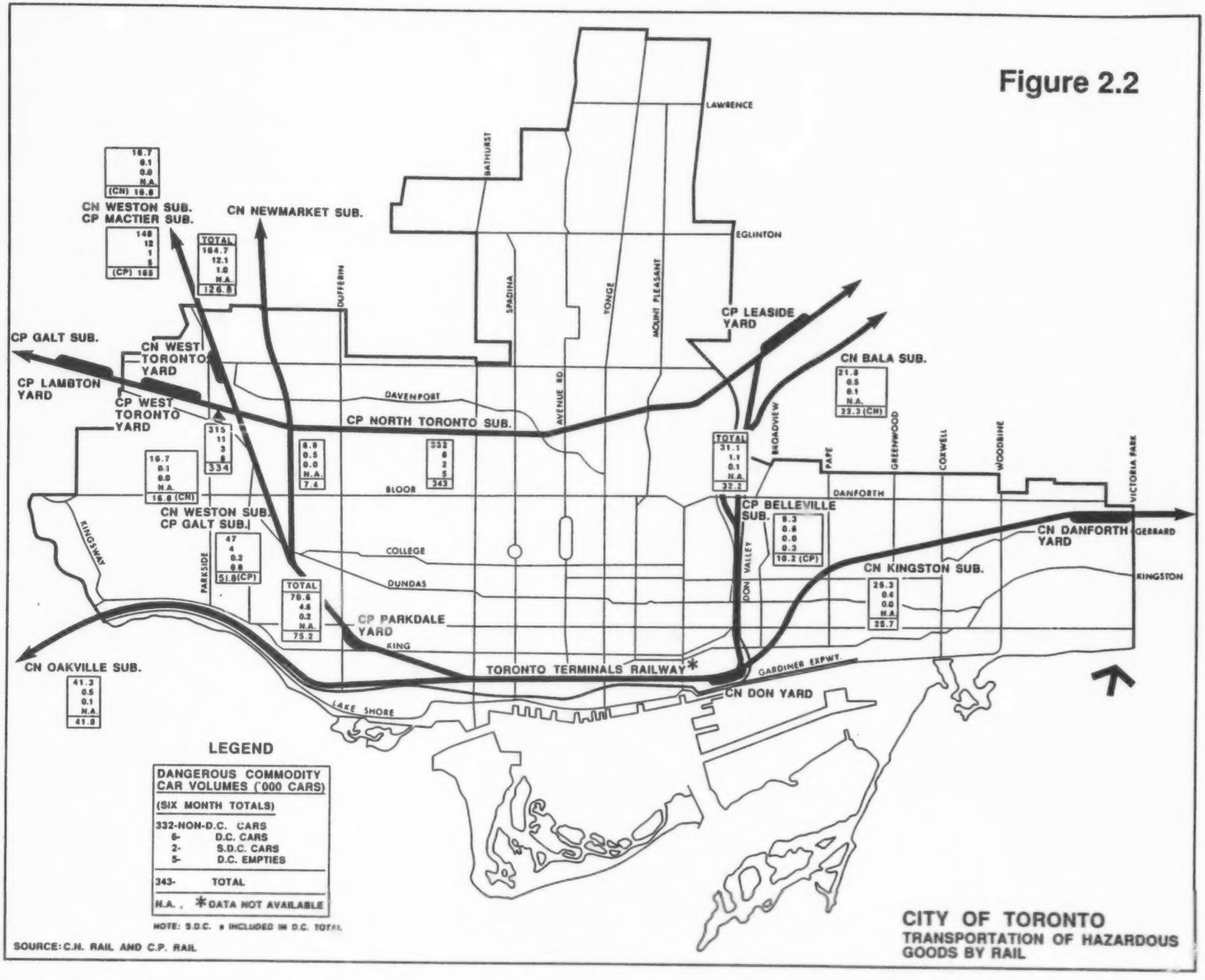
Figure 2.1


CN WESTON SUB.
CP MACTIER SUB.
3 (CN) 0 27
15 (CP) 11 15
CN NEWMARKET SUB.
18 (TOTAL) 11 42
5 0 10
CP GALT SUB.
CP LAMBTON YARD
CN WEST TORONTO YARD
CP WEST TORONTO YARD
41 26 46
3 (CN) 0 27
CN WESTON SUB.
*CP GALT SUB.
6 0 (CP) 12
6 (CN) 2 173
CN OAKVILLE SUB.
KINGSWAY
PARKSIDE
DUFFERIN
DAVENPORT
CP NORTH TORONTO SUB.
40 24 40
BLOOR
COLLEGE
DUNDAS
KING
(TOTAL) 14 0 48
CP PARKDALE YARD
LAKE SHORE
TORONTO TERMINALS RAILWAY
11 (CN) 3 201
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
LAWRENCE
EGLINTON
CP LEASIDE YARD
CN BALA SUB.
4 (CN) 1 23
5 1 (TOTAL) 24
CP BELLEVILLE SUB.
1 0 (CP) 1
DON VALLEY
PAPE
DANFORTH
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
GERRARD
KINGSTON
CN DANFORTH YARD
CN KINGSTON SUB.
7 3 88
GARDINER EXPWY.
CN DON YARD
LEGEND
SUBDIVISION TRAIN VOLUMES
(1985) (AVERAGE DAILY)
45 TOTAL FREIGHT TRAINS
17 SYMBOL FREIGHT TRAINS
73 TOTAL DAILY TRAINS
* DATA ADJUSTED TO REFLECT 1986 ACTIVITY

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

SOURCE: C.N. RAIL AND C.P. RAIL

Figure 2.2


LAWRENCE
BATHURST
EGLINTON
CN NEWMARKET SUB.
16.7
0.1
0.0
N.A.
(CN) 16.8
CN WESTON SUB.
CP MACTIER SUB.
148
12
1
5
(CP) 165
TOTAL
164.7
12.1
1.0
N.A.
126.8
DUFFERIN
SPADINA
YONGE
MOUNT PLEASANT
CP LEASIDE YARD
CN BALA SUB.
21.8
0.5
0.1
N.A.
22.3 (CN)
CP GALT SUB.
CN WEST TORONTO YARD
CP LAMBTON YARD
CP WEST TORONTO YARD
DAVENPORT
AVENUE RD
CP NORTH TORONTO SUB.
315
11
3
5
334
16.7
0.1
0.0
N.A.
16.8 (CN)
6.9
0.5
0.0
N.A.
7.4
332
6
2
5
343
BLOOR
TOTAL
31.1
1.1
0.1
N.A.
32.2
BROADVIEW
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
DANFORTH
CP BELLEVILLE SUB.
9.3
0.6
0.0
0.3
10.2 (CP)
CN DANFORTH YARD
GERRARD
KINGSWAY
CN WESTON SUB.
CP GALT SUB.
PARKSIDE
47
4
0.2
0.8
51.8(CP)
COLLEGE
DUNDAS
TOTAL
70.6
4.6
0.2
N.A.
75.2
CP PARKDALE YARD
KING
DON VALLEY
CN KINGSTON SUB.
25.3
0.4
0.0
N.A.
25.7
KINGSTON
CN OAKVILLE SUB.
41.3
0.5
0.1
N.A.
41.8
TORONTO TERMINALS RAILWAY*
GARDINER EXPWY.
CN DON YARD
LAKE SHORE
LEGEND
DANGEROUS COMMODITY CAR VOLUMES ('000 CARS)
(SIX MONTH TOTALS)
332-NON-D.C. CARS
6- D.C. CARS
2- S.D.C. CARS
5- D.C. EMPTIES
343- TOTAL
N.A. , *DATA NOT AVAILABLE
NOTE: S.D.C. • INCLUDED IN D.C. TOTAL

SOURCE: C.N. RAIL AND C.P. RAIL

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

Figure 2.2 shows the total number of freight cars traveling on the rail subdivisions in Toronto during the last half of 1985.* These are broken down into the number of cars carrying:

- dangerous commodities) for definitions see Chapter 1
- special dangerous commodities)
- non-dangerous commodities.

[Note: In the case of CP Rail links, the number of 'empty' tank cars which last carried dangerous commodities are shown. In the case of CN Rail links, these are included in the non-DC car totals. Tank cars which last contained DCs are of interest because of the controversy concerning their possibly hazardous behavior in rail accidents (see comments on page 148.

It must also be mentioned that car traffic volumes reported by CN and CP do not measure exactly the same things. CN utilizes 'car counts' in its statistics. A car is counted when it enters the subdivision; subsequent movements within the subdivision are not recorded.

CP, on the other hand, measures car traffic in 'car movements.' A car is recorded each time it is moved within the subdivision, whether its entire length or from place to place within the subdivision.

As a result, CP's car traffic figures can potentially be overstated relative to CN's figures. Due to the nature of movements on the CP network within the City of Toronto, one can expect that a one to one relationship exists between car movements and car counts. The sole important exception is the CP Mactier subdivision. Cars are often transferred to the Ray Yard in York, counting as one movement on this subdivision. Susequently, they are attached to a through (symbol) freight train heading northwards, counting as a second movement. As a result, CP estimates a two to one relationship between car movement figures and car counts. This is the only subdivision where this anomaly occurs within Toronto.

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* CP train and car volumes were obtained by halving the 1985 total figures. Since that time a symbol train has been dropped from the Galt/Weston corridor, which is reflected in Figures 2.2 and 2.3.

The reader is advised to keep this distinction in mind when comparing car traffic figures between the CN and CP systems.

Figure 2.2 shows the preponderance of freight car movements across the CP North Toronto and Galt east-west corridor, with over 330 000 freight cars traveling during the last half of 1985. By comparison, the lakeshore corridor carries about one-tenth of these freight volumes. Table 2.2 lists subdivision car traffic volumes and percentages.

The same patterns apply to DC and SDC traffic; with no SDC traffic on the Kingston subdivision and 100 SDC cars traveling on the Oakville subdivisions, compared to 11 000 and 6 000 DC cars on the Galt and North Toronto subdivisions respectively, (with 3 000 and 2 000 SDC cars on these two links).

The predominant links for the transport of DC cars are the CP Mactier-/CN Weston subdivision and the CP Galt subdivision west of the West Toronto Yard. These carried 12 100 and 11 000 cars respectively during this period (representing about 70 and 75 DC cars per day). The CP North Toronto subdivision on the other hand carries 6 000 DC cars (about 40 cars per day).

The heaviest SDC volumes are carried on:

- the CP Galt subdivision (west of West Toronto Diamond) - 3 000 SDC cars (17 per day)

- the CP North Toronto subdivision - 2 000 SDC cars (11 per day).

TABLE 2.2

DC CAR VOLUMES ('000 CARS*
(Six Month Totals - 1985)

(Note: SDC Carloads included in DC totals.)

Subdivision Corridors	Non-DC Cars		DC Cars		SDC Cars		DC Empties **		Total Cars	
	Total	%	Total	%	Total	%	Total	%	Total	%
CP Mactier/CN Weston	164.7	93	12.1	7	1.0	1	n.a.		177.8	100
CP Galt-Lambton	315	94	11	3	3	1	8	2	334	100
CP Galt/CN Weston/ Newmarket	70.6	94	4.6	6	0.2	0.3	n.a.		75.2	100
CN Oakville	41.3	99	0.5	1	0.1	0.2	n.a.		41.8	100
CN Kingston	25.3	98	0.4	2	0.0	-	n.a.		25.7	100
CN Bala/CP Belleville	31.1	97	1.1	3	0.0	0.3	n.a.		32.2	100
CP North Toronto	332	97	6	2	2	1	5	1	343	100
CN Newmarket	6.9	93	0.5	7	-	-	-	-	74	100

* Both CP car movements and CN car counts are included in this table. CP Mactier figures may therefore be overstated relative to CN. See p. 58 for discussion.

** 'Empties' here means 'tank cars which last contained DCs.'

Source: CN, CP Rail.

The CP Mactier/CN Weston subdivision carries a total of 1000 SDC cars (six per day).

The Galt/Weston sub carried only 300 SDC cars during the last half of 1985 (about two SDC cars per day), while the CP North Toronto subdivision carried 2000 SDC cars (some 11 SDC cars per day). Much of this traffic (on the Galt/Weston subdivision) is carried on slower-moving transfer and switching trains.

It should be noted that CP designates certain trains as primary trains for the transport of DCs - that is, to concentrate DC shipments on specific trains. These include:

- No. 955, Toronto to western Canada (daily) - mixed load,
- No. 918, Chatham to Montreal (daily) - mixed load,
- Unit Acid Train, Sudbury/North Bay to Hamilton/Windsor - sulfuric acid (average occurrence 3.0 times weekly).

Designated trains permit the carrier to maximize safety measures for concentrated hazardous loads while minimizing the number of trains operating at restricted speeds. That is, special crew and equipment, and operating practices can be applied to such trains, while speed restrictions are confined to DC shipments, i.e. designated trains.

CP Rail data permits us to record the number of trains specifically carrying dangerous and special dangerous commodities for each link on an average daily basis. These are shown below in Table 2.3.

2.2.1 - Patterns and Trends in DC Movements

Tables 2.4 and 2.5 represent 1985 breakdowns of total DCs in the Toronto CMA and the top 20 DCs on the North Toronto subdivision. This reflects current patterns on CP lines which represent over 90% of DC movements by rail within the City of Toronto. These tables are compared with data from the Burton/Post report. This provides a picture of five-year trends (i.e. 1980 to 1985). Although these tables are not directly comparable the following comments can be made.

TABLE 2.3

DC/SDC TRAINS PER DAY ON CP SUBDIVISIONS

Subdivision	Trains per day carrying Dangerous Commodities	 Special Dangerous* Commodities
Main Lines:		
North Toronto	7	3
Galt-Lambton	6	3
Mactier	6	2
Link Lines:		
Galt-Union	1	0.4
Belleville S.	0	0

* SDCs included in DC totals.
Source: CP Rail.

(i) Major Dangerous Commodities Transported

Tables 2.4 and 2.5 indicate there are three categories of DCs that represent major shipments through the Toronto area.

Corrosives. Sulfuric acid has increasingly become a major shipping commodity by rail in the Toronto area and is now the largest DC shipment in the Toronto CMA. This largely reflects the operation of the unit acid train from Sudbury travelling westerly via the Mactier

TABLE 2.4

BREAKDOWN OF DANGEROUS COMMODITIES THROUGH TORONTO CMA - 1985 - CP RAIL

Commodity Description	Percent of DC Traffic	Percent of SDC Traffic
Sulfuric Acid	25	
Mixed load - pool car	14	
Propane or LPG	13	48
Styrene liquid	4	
Caustic soda	3	
Mixed load - intermodal	3	
Methyl alcohol	2	
Isopropanol	2	
Chlorine	2	8
Oleum sulfuric acid	2	7
Isobutylene	2	6
Sulfur dioxide	2	5
Gasoline	2	
Propylene	1	5
Xylene	1	
Mixed load - cleaning materials	1	
Calcium oxide (lime)	1	
Sodium chlorate	1	
Antiknock compound	1	3
Ammonium nitrate fertilizers	1	—
	83	82

Source: CP Rail.

TABLE 2.5

TOP 20 DANGEROUS COMMODITIES ON THE NORTH TORONTO SUBDIVISION - CP RAIL (1985)

	1985 Car Totals	
Commodity	DC Cars	SDC Cars
Propane	2 785	2 785
Mixed load - pool car	1 276	
Mixed load - container or trailer	958*	
Styrene liquid	912	
Methyl alcohol	906	
Sulfuric acid	717	
Sulfur dioxide	611	611
Lime	431	
Isopropanol	424	
Isobutylene	332	332
Mixed load - cleaning materials	292	
Caustic soda	268	
Sodium chlorate	216	
Mixed load - acids, chemicals, or other articles	214	
Ethyl alcohol	192	
Vinyl acetate	187	
Xylene	181	
Ammonium nitrate fertilizers	170	
Acrylonitrile	156	156
Oleum sulfuric acid	141	141
	11 369	4 025

* This figure represents containers or trailers, not car loads. There are usually 2 to 4 containers or 2 trailers per car.

Note:

The figures listed here can be considered car counts and not just car movements (car movements were used to determine breakdown percentages of DCs through Toronto CMA). This is because there is no point on the North Toronto subdivision where cars are set-off to be lifted by another train thus resulting in 2 movements.

Source: CP Rail.

subdivision transferring to the Galt subdivision. In response to the increase in sulfuric acid shipments the RTC has commissioned extra inspections to ensure that the acid trains and equipment used are adequate.

LPGs. Propane represented in 1985, 48% of SDC shipments in the Toronto CMA. It also constitutes 24% of DC shipments on the North Toronto subdivision.

Toxic Gases. Major commodity shipments include sulfur dioxide and oleum sulfuric acid. Sulfur dioxide is transported as compressed gas in tank cars. Upon release it expands rapidly as a gas with toxicity levels similar to chlorine. Oleum sulfuric acid in moist air can produce a corrosive gas three times as toxic as chlorine.

(ii) Patterns and Trends

Predominant movement of DC shipments in the Toronto area is easterly, e.g. on the North Toronto subdivision in 1985:

DC loads eastbound outnumber westbound 1.7 to 1.
SDC loads eastbound outnumber westbound 3.2 to 1.

Comparison with Burton/Post data (Table 5, page 34 -see below) indicates distinct changes in the mix of commodities carried, for example,

- decreases in shipment levels of flammable liquids (i.e. gasoline),
- an increase in the amount of corrosives carried (this reflects the increase in sulfuric acid transport).

These patterns, while reflecting a possible decrease in certain special hazard commodities, in fact are significant in indicating major changes over a three-year period. These can be interpreted to depict widely

From Burton/Post Report - page 34.

TABLE 5

TWENTY MOST FREQUENTLY TRANSPORTED DANGEROUS COMMODITIES (1980) CP RAIL

(Compiled for Toronto Region operations)

COMMODITIES:	TANK CARS	OTHER	TOTAL CARS
Propane	15,817	491	16,308
Gasoline	11,882	32	11,914
Sulphuric Acid	8,551	65	8,615
Anhydrous Ammonia	7,819	116	7,935
Pool Car Traffic	-	4,503	4,503
Butane	4,057	154	4,212
Butane Impure for Further Refining	4,130	37	4,167
Methanol (Wood Alcohol)	4,097	11	4,108
Ammonium Nitrate Fertilizer	-	3,335	3,335
Crude Oil Petroleum	2,443	16	2,459
Sulphur Dioxide	1,774	16	1,790
Sodium Hydroxide Liquid or Solution	1,668	18	1,686
Chlorine	1,344	19	1,363
Alcohol N.O.S. (Liquor)	138	1,162	1,300
Isobutane for Further Refining	1,267	14	1,280
Sodium Chlorate	59	811	870
Liquified Petroleum Gas	763	53	816
Aviation Fuel	777	1	778
Mixed Load TOFC	-	577	577
Petroleum Naptha	389	15	404

varying demand patterns on the railways, thereby opening up a wide range of possibilities. That is, changing patterns make it difficult to forecast future DC traffic by subdivision.

Trends in traffic levels. By comparing subdivision data from in the Burton/ Post report, and Figure 2.2 above, the following six-month volumes on rail subdivisions in Toronto are computed for 1982 and 1985 conditions and are shown in Table 2.6 below.

TABLE 2.6

CHANGING LEVELS OF DC VOLUMES

(In this table 1985 data has been adjusted to achieve comparability with 1982 records.)

Rail Corridors	1982	1985	Change (%)
	(DC Carloads - six months)		Number of Carloads)
CP North Toronto	6 489	5 205	-1 284
Mactier/CN Weston*	5 122	4 794	-328
CP Galt (west of West Toronto Yard)	9 286	8 614	-672
CP Galt/CN Weston/CN Newmarket*	1 281	1 516	+235
CP Belleville/CN Bala*	79	608	+529
CN Kingston	25	425	+400
CN Oakville	2 103	461	-1 642
CN Newmarket	609	546	-63

* Data combined for parallel subdivision corridors.

Source: Burton/Post report, CP Rail, CN Rail submissions (1986).

Table 2.6 is based on data provided by CP Rail and CN Rail and depicts significant changes in traffic levels between 1982 and 1985. These include decreases in traffic on the Oakville, Galt/Weston and Newmarket corridors, with increases on the Belleville/Bala and Kingston corridors. These changes over a five-year period reflect the shifting conditions of rail demand volumes in this area and the year-to-year uncertainty which appears to characterize transport demand patters.

Through Trips. A key rail traffic statistic is the amount of through DC or non-DC traffic on Toronto lines. That is, what shipments bypass the Toronto CMA and as a result qualify for diversion. At the heart of the current controversy is the question of exposure of the population resident and/or employed in Toronto to the hazards of potential rail mishaps. Figures 2.6 and 2.7 on pages 103 and 104 respectively depict the areas covered by the medium- and high-consequence zones. The numbers of population and employment estimated to be included in these zones are shown as follows:

Public Exposure in Accident Consequence Zones (City of Toronto Totals)

Consequence Zone Type*	**Total Population in Zone****	**% of City Total**	**Total Employment in Zone**	**%of City Total**
High C.Z.	97 400	16.0%	88 800	17.3%
Medium C.Z.	338 783	53.5%	266 900	52.1%

* For definition see page 100.

** Specific accidents affect limited number of persons (see Section 2.6)

In Chapter 3, the subject of measures to alleviate potential hazards is discussed. A major category covered involves the possible reduction of the amount of dangerous goods traffic passing through Toronto, including the diversion of dangerous commodity shipments. This option represents a key strategic opportunity and concerns the amount of DC or SDC traffic that hypothetically can be diverted from Toronto subdivisions to other rail facilities. Accordingly, estimates of possible bypassable traffic are needed in order to indicate the likely levels of benefit from diversionary options; that is, those DC trips (carloads) that are neither destined for, or originating in the Toronto CMA. A given in this subject is that locally-based traffic serving city industry will not be interfered with. This will include transfer trains between yards and switching trains directly serving industrial sidings.

Unfortunately, the carload statistics data acquired do not reflect the numbers of carloads of freight passing completely through the Toronto CMA, and therefore capable of being diverted around the area. The only available reference is a memo prepared by the CP in May, 1983, "CP-Rail's Response to the Railway Transport Committee Report - The Transport of Dangerous Commodities by Rail in the Toronto Census Metropolitan Area - A Preliminary Assessment of Risk" (i.e. the Burton/Post Report).

In Section 4.1 (Local Traffic Must Remain), the following statement is contained:

> "During the study period January to June 1982, 810 cars or 8.1% of CP Rail's total dangerous commodity traffic, terminated in the Toronto Census Metropolitan Area. These cars will continue to be handled on mainline trains and industrial switching assignments to industrial areas near Toronto Harbour, Lambton, Streetsville, Weston, and on the Oakville joint section.
>
> Nearly 13% of CP Rail's dangerous carloads originated within the Toronto CMA. These 1 207 carloads also will continue to be handled by industrial assignments into Lambton or Toronto Yard for connections on trains departing the CMA.
>
> In total, 2 017 carloads or 21.2% of all CP Rail dangerous commodities are to or from local industries, and will thus remain on their present corridors. Over 425 of these cars are considered to be 'special dangerous'. Since there were just over 2 500 special dangerous carloads handled by CP Rail into and out of the CMA during the study, this would leave approximately 2 100 cars that could have been diverted via the CNR."*

The Table 2.7 following has been prepared representing our judgement as to the proportion of 'through' DC and SDC trips on each subdivision.

---

* Above based on January to July 1986 data.

Table 2.7 provides rough estimates of the likely divertible 'through'-rips from the various subdivisions within the City of Toronto, and indicates possible levels of relief to corridor populations from exposure to dangerous commodity traffic. Figure 2.3 has plotted these values on the Toronto rail network. These figures show that the three major locales of benefit from diversion of DC carloads to other routes or bypasses are the North Toronto, Galt (west of North Toronto diamond) and Mactier/Weston subdivisions. The bulk of the DC traffic in these subdivisions are travelling on CP routes. With the passage of time such trip patterns can change.

TABLE 2.7

RAIL TRAFFIC WITH ORIGINS AND DESTINATIONS OUTSIDE OF THE TORONTO CMA

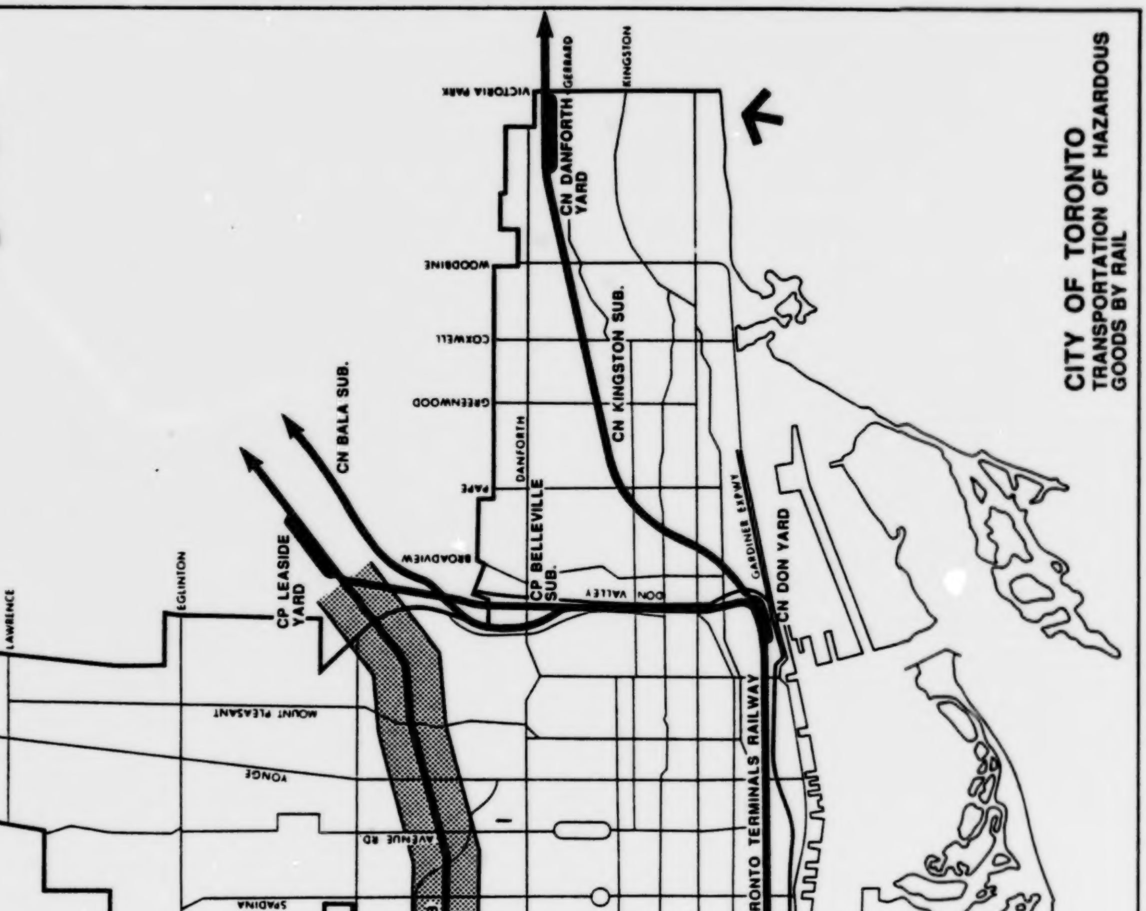
Rail Subdivisions	**1985 Car Movements**					
	Total		**Through***			
	DC	**SDC**	**SC**	**%**	**SDC**	**%**
CP N. Toronto	12 452	4 554	9 339	75	3 416	75
CP Weston	12 120	1 055	11 029	91	960	91
CP Galt (W. of N. Tor. yard)	22 396	5 456	17 245	77	4 201	77
CP Galt/CN Weston	4 666	262	280	6	16	6
CP Belleville/CN Bala	1 785	106	143	8	-	-
CN Kingston	425	-	43	10	-	-
CN Oakville	461	73	46	10	7	10
CN Newmarket	546	7	-	-	-	-

* Consultant's estimate based upon best available data.

Source: CN and CP Rail.

Although the Galt/Weston subdivision link carries relatively heavy DC loads, it is assumed that most of these are moving as part of transfer or switching trains and are not divertible external-to-external rail freight movements. This represents one link of fairly heavy DC load movements which would not be significantly relieved as a result of a

Figure 2.3


CN NEWMARKET SUB.
CN WESTON SUB.
CP MACTIER SUB.
CP GALT SUB.
CP LAMBTON YARD
CN WEST TORONTO YARD
CP WEST TORONTO YARD
CN WESTON SUB.
CP GALT SUB.
CP NORTH TORONTO SUB.
CP PARKDALE YARD
CN OAKVILLE SUB.
CP LEASIDE YARD
CN BALA SUB.
CP BELLEVILLE SUB.
CN KINGSTON SUB.
CN DANFORTH YARD
CN DON YARD
TORONTO TERMINALS RAILWAY
LAWRENCE
EGLINTON
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
DUFFERIN
PARKSIDE
KINGSWAY
DAVENPORT
BLOOR
COLLEGE
DUNDAS
KING
LAKE SHORE
BROADVIEW
DON VALLEY
PAPE
DANFORTH
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
GERRARD
KINGSTON
GARDINER EXPWY
LEGEND
THROUGH D.C. TRIPS
(1985 CAR LOADS)
2000
1500
1000
500
0

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

SOURCE: C.N. RAIL AND C.P. RAIL

bypass route or traffic diversion. On the other hand, most of the traffic on this link (about 75%) is made up of transfer or switching movements with smaller train lengths (i.e. 67 cars per symbol train versus only 34 cars per transfer train), and lower speeds with likely less rail operating hazard levels. As well, the SDC volumes on the Galt/Weston subdivision represent about one tenth of that traversing the North Toronto subdivision.

It should be noted that the carload figures in the above table do not include tank cars which last contained DCs.

CP Rail data permits the estimation of DC/SDC trips through Toronto having both origin and destination with the US. This is tabulated as follows:

TABLE 2.8
US TO US TRAFFIC

Subdivision	**Percent of Total DC Carloads**	**Percent of Total SDC Carloads**
North Toronto	1.1	0.7
Galt (at West Toronto Yard)	0.6	0.6

2.3 - INCIDENT SCENARIOS

In discussing the occurrence of dangerous events on rail service, three consecutive steps are considered: an accident occurring on the rail line, a subsequent release of a dangerous substance, and an incident taking place with potential hazard for adjacent persons and property. In estimating the final probability of hazard, the combined probability of the above three occurrences must be determined. In the following discussion, the definition of these three stages of hazard occurrences are based upon a number of assumptions or definitions:

- Accidents considered for this analysis represent essentially major occurrences including one or more of the following RTC definition).
  - a derailment,
  - a collision between rail vehicles,
  - damages exceeding $750,
  - the involvement of a dangerous commodity,
  - personal injury or death.

- Releases cover the following categories of dangerous commodity
  - nonflammable toxic compressed gases (e.g. chlorine, anhydrous ammonia),
  - flammable compressed gases (e.g. LPG--propane, butane, propylene),
  - corrosives (e.g. sulfuric acid, oleum),
  - flammable liquids (e.g. gasoline, toluene, methyl alcohol),
  - combustible liquids (e.g. kerosene, fuel oil),

  The above categories represent substances with a relatively high probability of hazardous occurrence upon release from carrying vehicles, plus some frequency of occurrence in rail traffic movements in the Toronto area.

- Incidents. The above six categories of dangerous commodities following release can be involved in a variety of hazardous occurrences. Of these, the six types of incident discussed below have been selected as the most significant in public hazard considerations, and will form the basis of the following interpretation and discussion (these are based upon the research covered in papers number 1, 2 and 3 listed in the End Notes). The six incident types are listed and discussed as follows:

  3.1 Torch Fire
  3.2 Pool Fire
  3.3 Vapor Fire

3.4 Unconfined Vapor Cloud Explosion
3.5 BLEVE
3.6 Release of Toxic Gases.

In the above analysis, accident probabilities are based on Canadian data, while substance release and incident occurrence are based on US results; incident criteria are based on the total release of the contents of a ruptured tank car. Probability data are not available for partial release, which would be higher than full escape.

2.3.1 - Torch Fire (Flame Jet)

These result from the ignition of relatively small leaks of flammable compressed gases (primarily LPG) from cracks in tank containers, stuck vent valves or relief valves operating automatically. This produces what is essentially a large blowtorch consisting of a jet of flame approximately 100 to 200 times the escape hole diameter in length. The area of personal hazard extends well beyond the actual range of the torch fire plume. A torch fire occurring in a rail yard could impinge on DCs in adjacent cars with hazardous effects.

2.3.2 - Pool Fire

This can occur in the case of the release of flammable liquids and liquified compressed gas. This can result in the formation of a pool of liquid on the ground in the vicinity of the carrying vehicle. Upon ignition the vapor pad above the pool burns, causing a continuing pool fire. The principal hazard from a pool fire is thermal radiation threatening both adjacent structures and persons.

2.3.3 - Vapor Fire (Flash Fire)

In the case of flammable compressed gases (usually LPG), immediately following a tank car release a heavy gas cloud puff or plume may be formed. Depending upon the rate of emission, ignition can assume two forms. In the case of a slow release rate, a dense vapor layer forms, providing a minimal air mix. This will burn slowly in a surficial or "clothes line" fashion. In the case of a rapid or jet-like release, a greater air mix will occur, causing a flame front burning from the point of ignition to the release source. The latter manifestation would be expected to have the more severe and sudden impact on surroundings. Opinion of fire service personnel is that the latter case occurs more frequently.

2.3.4 - Unconfined Vapor Cloud Explosion

This deals with the dispersion following a release of a flammable gas in large amounts into the atmosphere in low-density concentrations. Under certain circumstances the resulting cloud can ignite to produce an unconfined explosion usually consisting of a relatively slow burning expansion of the vapor cloud.

2.3.5 - BLEVE

The exposure of a tank containing compressed flammable gas (e.g. LPG) to fire can result in a BLEVE (Boiling Liquid Expanding Vapor Explosion) consisting of the following events. First, the boiloff from the heat input is vented into the atmosphere through the relief valve on top of the tank car. This gas outflow is ignited and forms a torch fire. Second, the tank wall not backed by liquid inside overheats and weakens. Failure of the tank wall is sudden, resulting in the rupture of the tank wall, instantaneous release of remaining contents, and ignition of the contents. This ignition results in the formation of a spectacular fireball.

It should be noted that a BLEVE can occur without exposing the tank wall to flame. This can occur as a result of the rupture of a tank car leading to a rapid decompression, ignition and fireball explosion, a result similar to the flame-induced BLEVE sequence.

BLEVE's are a devastating event producing both blast impact and highly destructive and life-threatening heat radiation. Again it should be noted that in the case of a non-flammable compressed gas such as carbon dioxide, a ruptured tank shell would produce a severe decompression blast.

The recent widespread retrofitting of tank cars in the form of an outer shell of thermal insulation plus head shields at each end, provides significant protection against the occurrence of BLEVEs. The AAR performance specification defines this as ".... prevents the release of any of the car's contents [except release through the safety relief valve] when subjected to: (1) a pool fire for 100 minutes; and (2) a torch fire for 30 minutes".[4] The foregoing representing a performance standard to ensure the venting of virtually all of the tank car's contents prior to rupture thereby precluding a possible BLEVE. In the case where the thermal shielding is breached in a collision, a BLEVE may occur.

2.3.6 - Release of Toxic Gases

A major dangerous commodity hazard potential involves the possible release of a toxic gas such as chlorine (2% of DC volumes transported by rail).

Note: Three toxic gases are listed below with comparative characteristics.

Gas	Threshold Limit Values (TLVs)
Phosgene	0.1 ppm
Chlorine	1.0 ppm
Anhydrous ammonia	25.0 ppm

[TLVs represent chronic workplace limits for continual human exposure (as opposed to acute levels experienced in a sudden disaster) and are included to compare the relative toxicity of different gases.]

* * * * * *

The above discussion covers six DC incidents selected for the purpose of assessing public hazard. The compounds mentioned were selected to demonstrate the effects of rail-transported DC accidents. Other materials, with less probable incidence, also cause hazardous occurrences. These cover such categories as

- corrosive materials
- combustible/flammable solids
- explosives
- poisons.

As well, it should be noted that rail vehicles with or without the presence of dangerous commodities constitute a physical threat to the adjacent communities as a result of the strictly physical impact of train accidents (e.g. derailments, collisions, etc). The current study, however, is confined to the effects of accidents involving DCs.

2.4 - PROBABILITY OF HAZARD

Government and industry commonly frame program or policy decisions in relation to expected probabilities or risks. This is done in:

- flood plain development,
- zoning in the vicinity of airports,
- hydroelectric system design, etc.

The process usually followed is for public authorities to decide on the acceptability of courses of action on the basis of the probability of certain events. For example, in the case of land-use planning for flood plains, hypothetically a three-foot flood could occur every 200 years. Accordingly, a council could decide whether estimated expenditures for protective measures were justified or not; and whether the land could be zoned for a particular class of development.

Public utilities such as railways or highways represent long standing investments and facilities with intrinsic values to the community at large. Any major disruption or revision of such assets should only be made on the basis of clearly established and understood benefits to the public. The federal legislation regulating the development of urban rail relocation schemes establishes a condition of equal benefit to the parties involved. Accordingly, authorities can evaluate rail service options on the basis of relief to established accident probabilities and consequences in relation to service and industrial consequences and other community impacts.

An objective of the current study is to present to the authorities in Toronto a meaningful picture of the likelihood and consequences of rail DC accidents. Railway and air transport services are the most highly controlled modes of transport. Yet there is a higher public perception of accidents experienced on them. This is perhaps a result of the heavy consequences of such accidents in terms of human injuries and fatalities and property damage. We perceive the task of evaluating the high price of minimizing the exposure of the public to DC movements as one of assessing both the potential high consequences and low probability of railway accidents involving the release of dangerous commodities.

Railway accidents consist of a number of mechanical occurrences with the main categories being derailments and collisions. For the purposes of this study such accidents must be accompanied by a release of toxic materials and subsequent public exposure to these substances, and/or their ignition or explosion.

In order to estimate the probability of such public hazards, a sequence of three calculations must be carried out--that is, to determine the probability of:

(i) the initial mechanical accident to the railway train (derailment, collision),
(ii) the release of a hazardous substance (gas, liquid, or solid),
(iii) the incident exposing the community to hazard.

2.4.1 - Effect of Retrofit

In order to carry out the above statistical analysis, a variety of data must be referred to which reflects the relationship between the designated events and the characteristics of the rail network and its traffic levels in order to develop factors for analysis and forecasting. Difficulties were encountered concerning the availability of current and representative data.

Over the past eight years in Canada and the US a major program of retrofitting for safety purposes of tank cars and other rolling stock has been carried out. This has entailed the introduction of such safety measures as:

- wheel roller bearings,
- double shelf couplers on tank cars,
- head shields on tank cars,
- thermal insulation on tank cars,
- bottom fitting protection on tank cars.

The periods during which most of the rail car fleets in the US and Canada were retrofitted are found in Chapter 1, pages 23 to 25.

2.4.2 - Incident Probability Forecasts

The recent sequence described above, of widespread equipment retrofitting has brought about the urgent need for up-do-date data on the levels of safety performance currently in effect as a result of retrofit. By using sources of up-to-date accident, substance release, and hazardous occurrence data, probability levels for the Toronto rail network have been computed and are shown in Table 2.9. The sources of the factors used in developing the data recorded in Table 2.9 are listed as follows.

(i) Railway accident factors:

An examination of Canadian Railway Derailments and Collisions, January 1, 1984 to March 21, 1986.
Canadian Transport Commission, March 26, 1986.

(ii) Rail traffic and DC volume factors

CP Rail, Submission to Federal Task Force, May 1986.
CN Rail, Submission to Federal Task Force, April 1986.
Burton/Post Report, 1983.

(iii) Hazardous incident factors

Generating Hazardous Material Risk Profiles on Railroad Routes, Raj and Glickman, Transportation Research Board Conference, November 10, 1985.

TABLE 2.9

PROBABILITY OF RAIL SYSTEM ACCIDENTS, RELEASES AND HAZARDOUS INCIDENTS

1. Total subdivision mileage within the City of Toronto	30.88
2. Total train miles (1985)	104,929

INCIDENT TYPE	PROBABILITY RANGE (time period of occurrence in years)
3. Estimated frequency of train derailment or collision within Toronto* (2.77/million train miles)	3.4
4. Estimated frequency of major DC release**	120 - 160
5. Estimated frequency of flammable compressed gas release***	450 - 1 000
6. Estimated frequency of poisonous or corrosive ~~liquid~~ gas release***	1 300 - 3 800
7. Estimated frequency of flammable liquid release***	700 - 1 800
8. Estimated frequency of corrosive liquid release***	550 - 1 000
9. Estimated frequency of release of all other unspecified DCs of any class***	300 - 400

Listed below are estimated frequencies of a number of flammable compressed gas incident types (based on Raj and Glickman paper).

10. Torch Fire	800 - 1 700
11. Pool Fire	1 500 - 3 400
12. BLEVE	9 100 - 20 000
13. Vapor Fire	17 000 - 38 000
14. Unconfined Vapor Cloud Explosion	75 000 - 160 000

---

* RTC, March 26, 1986, pages 9, 11.

** CP Rail, Submission to Federal Task Force.

*** Raj and Glickman.

In our opinion the above sources provide a good base of rail operating experience reflecting the effects of the above-mentioned rail retrofit process.

(Note: The methodology followed in calculating probabilities is discussed in Appendix C.)

Our perception is that the risk analysis of the probability of future transportation hazards is a blunt instrument at best. Because of the many variables and assumptions involved in accidental cause and effect, the process of extrapolating experience from other environments to Toronto conditions with any degree of accuracy is unlikely. Factors affecting the results of risk analysis forecasts include:

- the uncertainty of future demand, and the likelihood of new chemicals being transported for industrial use,

- various analytic assumptions (e.g. the use of train miles in the analysis without reference to carloads per train),
- other areas of uncertainty which are discussed below in the text (i.e. demand uncertainty, DC storage control, engineering standards of containers, possible trespassing and vandalism) could affect future accident/incident levels.

Accordingly, we wish to note the inevitable uncertainty with rail accident probability forecasting such as listed in Table 2.9. This table is intended to provide an estimate of likely future conditions of risk in Toronto associated with the different categories of DC incident. The resulting probability figures have been recorded in ranges which are intended for use of order-of-magnitude comparisons between the relative probability of basic incident types.

Note: Table 2.9 figures were based on tables listing the top 20 DCs transported in the Toronto CMA; in 1982 for CN, and in 1985 for CP.

This results in many commodities transported in small amounts not being included in their respective classes. It can be assumed therefore that items 5 and 8 are underestimated.

2.4.3 - Additional Hazard Factors

It can be argued that performance data from the above sources do not entirely reflect likely rail safety conditions in Toronto since:

- they reflect national or continental averages, with a strong influence of rural conditions where the environment and operating standards differ from those found in urban conditions;

- some data is based on US and/or AAR data reflecting either US or Canadian/US rail network operations, heavily weighted by US experience.

It should be noted that the research data applied specifically reflects conditions of the post-retrofit period of some four to six years. Nevertheless it might be argued that, for the reasons listed above, the factors may overstate the accident and incident probabilities on the highly controlled Toronto rail system. At the same time, it should be mentioned that there are a number of important ambient conditions along the rail lines in Toronto that may affect rail safety on these corridors. These are discussed as follows.

(a) - Containers on Flat Cars

Comments have been made by officials of both the CTC in Ottawa (S. Caplan, Director, Dangerous Goods Division) and the National Transportation Safety Board in Washington (C. Batten, Chief, Hazardous Materials and Pipeline Accident Investigation Division) concerning the increasing rail traffic of containers on flatcars (including box and tank containers) as representing a potential hazard for the following reasons:

- Most containers enter Canada from other countries and are not subject to the same standards and controls as rail rolling stock, leading to such concerns as:

  - The need for inspection of containers for safety status?
  - Extent of use of double-shelf couplers on cars carrying containers?
  - Provision of headshields on tank containers or flat cars?

- Tank containers are subject to international ISO standards which are considerably short of current structural standards of rail tank cars. 'Tanktainers' carry a wide range of liquids and gases, with the bulk of shipments constituting flammable liquids and gases.

- Containers, both box and tank, are fastened to flat beds and could be dislodged in derailments or collisions.

- According to CP Rail, in 1985 tanktainers served import commodities and made up 500 out of a total of 100 000 containers on CP operations.

- The RTC is currently investigating a perceived hazard caused by inadequate packing of dangerous commodities in box containers which result in leaks of DCs. A recent CTC report documented how a test of 300 box containers entering at eastern Canadian ports revealed that over 50% of box containers carrying DCs contained inadequate blocking and bracing of load within the container, representing a potential DC leakage condition.

In a recent edition of the Toronto Globe and Mail (Report on Business, June 23, 1986) the following comments are made on the future of the shipping of containers by rail:

> "The movement of goods in containers and highway trailers piggybacked to their destination on rail flatcars has become the fastest growing segment of the railway industry, ..."
>
> "Last year CN Rail and CP Rail carried about 900 000 TEUs (20-ft equivalent unit containers or trailers) .... ."
>
> "This 'intermodal' service of truck-train-truck combination is regarded as the way of the future for the railways in fending off strong competition from the trucking industry in the transport of consumer and industrial goods as opposed to the carriage of bulk items .... ."
>
> "CN Rail has some 3000 container units and CP Rail has more than 2000 .... ."
>
> "With deregulation we (as shippers) expect to see a quantum leap in the provision of new and innovative packages by the railways through container services."(J. Dion, Canadian Industrial Traffic League.)
>
> "In using the container instead of the boxcar the railways can truck it to the shipper to be loaded, instead of building a siding and then truck it direct to a rail terminal, instead of having to switch it through rail yards, place it on a train of flatcars, take to a destination terminal, pick it off with a crane and truck it to the door of the customer for the goods."
>
> "Intermodal service now accounts for about 12% of total rail freight volume in Canada, the railways say, and it is forecast to reach 20% by 1990. Its growth has averaged about 13% a year since 1980."

The current record of this mode does not provide proof of a safety problem. However, the circumstantial evidence of possibly inadequate standards of tanktainers indicates the necessity for a review of engineering standards and possible public hazards, particularly in light of the rapid growth of intermodal services.

(b) - Storage of Dangerous Commodities

A possible hazard is presented by the current situation whereby various parties are responsible for the storage of DCs in the vicinity of rail rights-of-way, i.e.

- on rail rights-of-way, authority vested in Railway Transport Committee,
- off rail rights-of-way, authority vested in the Fuel Safety Branch of Ontario Ministry of Consumer and Commercial Relations. LPG storage must be licensed. Other substances must satisfy minimum storage design standards, as inspected by Municipal, and in some case, provincial officials.

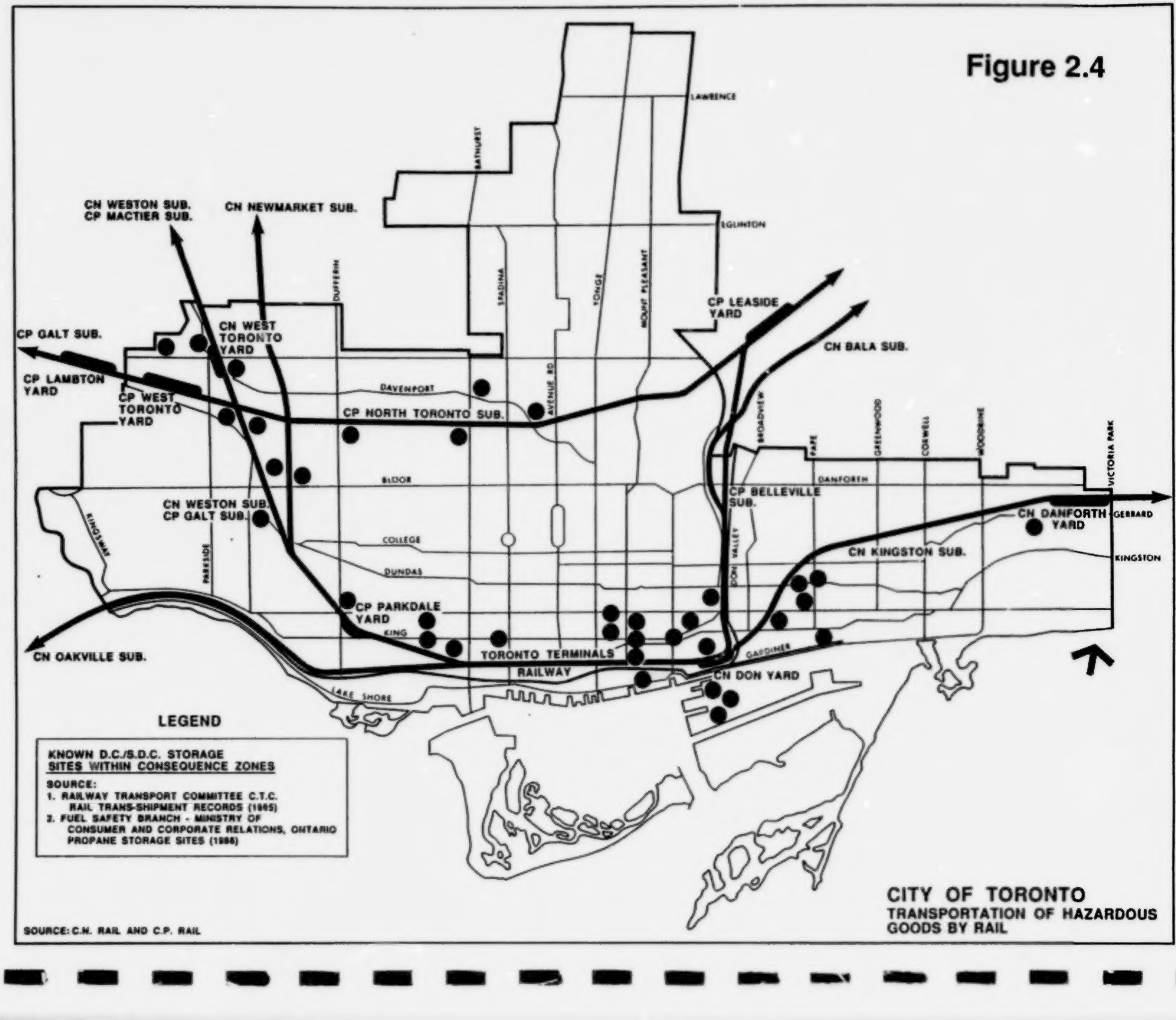
We feel that this situation represents a serious concern since approvals for locating storage structures for DCs in the same area, may be made without appropriate collaboration between the various affected parties. (Figure 2.4 indicates current sites for storage of DCs in the vicinity of railway rights-of-way in Toronto.)

(c) - Trespassers and Vandals

Obviously rail rights-of-way located in proximity to dense populations will be subject to frequent trespass (particularly when the railways are obliged by statute to provide only a light cattle-type fence along the boundary). Reports and observation indicate that such trespass is widespread and frequent, and represents an ongoing concern to railway management.

Public complaints are received concerning the visible decline in the number of railway line personnel patrolling the tracks. As explained by railway officials, current methods make it possible

Figure 2.4



CN WESTON SUB.
CP MACTIER SUB.
CN NEWMARKET SUB.
CP GALT SUB.
CP LAMBTON YARD
CN WEST TORONTO YARD
CP WEST TORONTO YARD
CP NORTH TORONTO SUB.
CN WESTON SUB.
CP GALT SUB.
CP PARKDALE YARD
TORONTO TERMINALS RAILWAY
CN OAKVILLE SUB.
CP LEASIDE YARD
CN BALA SUB.
CP BELLEVILLE SUB.
CN DON YARD
CN KINGSTON SUB.
CN DANFORTH YARD
LAWRENCE
EGLINTON
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
DUFFERIN
DAVENPORT
BLOOR
COLLEGE
DUNDAS
KING
LAKE SHORE
GARDINER
KINGSWAY
PARKSIDE
DON VALLEY
BROADVIEW
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
DANFORTH
GERRARD
KINGSTON

LEGEND

● KNOWN D.C./S.D.C. STORAGE SITES WITHIN CONSEQUENCE ZONES

SOURCE:
1. RAILWAY TRANSPORT COMMITTEE C.T.C. RAIL TRANS-SHIPMENT RECORDS (1985)
2. FUEL SAFETY BRANCH - MINISTRY OF CONSUMER AND CORPORATE RELATIONS, ONTARIO PROPANE STORAGE SITES (1986)

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

SOURCE: C.N. RAIL AND C.P. RAIL

to adequately monitor the line facilities for defects and maintenance needs by using fewer staff than previously. Nevertheless, they express pessimism about their ability to fully protect the rights-of-way from trespassers.

Trespassers do not commonly enter the railway property for nefarious purposes; the right-of-way is simply an obstruction in a path that, apparently, some local residents wish to use. Nonetheless, the trespassers cannot but be aware that they are breaking the law.

The desire of certain individuals to use these illegal routes has led to fences being trampled or cut, sometimes within hours of their installation. The fact that these fences are intended to protect the community is of no consequence. Some citizens see rail rights-of-way as easily traversible. The railways are most concerned about the danger to the trespasser rather than likely mischief or vandalism.

Although, according to railway representatives, there has been a minimal record of mischief, vandalism or sabotage on the tracks in this area, we do not believe that we can rely on such a satisfactory state to continue indefinitely. Concerns have been expressed concerning the improbable but possible likelihood of heavily trafficked lines being selected as targets for terrorism. Later in this report we will present a proposed policy for priorizing security measures on rail facilities in relation to the level of potential hazards existing on the different route links. We believe that in consideration of the numbers of population exposed along heavily travelled lines, this matter deserves special attention and effective action by the authorities.

2.4.4 - Application of Accident Factors

Acceptance of risk is a major factor in many personal, governmental or business decisions. For example, individuals smoke cigarettes or participate in high-risk activities (e.g. skydiving, motor cycling, skiing) apparently because the personal returns are worth the risk. In the case of government, certain levels of risk are accepted for the purposes of public action. For example:

- The City of Toronto uses the 350-year flood levels as the basis of storm sewer design and land use zoning; that is, any flood condition that has a lower probability than once in 350 years is not worth a public commitment. This decision likely reflects both probability and the consequences of the event.

- The same principle is applied in the case of:
  - . traffic engineering--the 30th highest traffic hour for road design,
  - . hydroelectric engineering--a particular flood (every so many years) for powerhouse design,
  - . urban airports--zones of probability of air crashes as the basis of land use zoning standards.

It is suggested that a similar approach can be taken to policy decisions involving the presence of railway service in Toronto. Corridor analysis indicates that 53.5% of the City's population, 52% of employment and 56% of school children are located within the accident consequence zones of the railway network (see Figures 2.5 and 2.6 for extent of accident consequence zones in City of Toronto.)

By comparing the probability and consequences of the major hazard incidents, authorities can address the decision to either accept the existing (and anticipated) level of hazard, or not. The findings recorded in Table 2.9 are listed below according to the six specific hazard incidents under consideration.

Within the City of Toronto*:

(i) Torch Fire - once every 800 to 1700 years

(ii) Pool Fire - once every 1500 to 3400 years

(iii) Vapor Fire - once every 17 400 to 38 000 years

(iv) Vapor Cloud Explosion - once every 75 000 to 160 000 years

(v) BLEVE - once every 9 100 to 20 000 years

(vi) Release of toxic gas (chlorine) - once every 1300 to 3800 years.

Probabilities can be computed for individual incidents, as above, or for the probability of one of several incidents occurring. For example, the chance of occurrence of one of three incident types (of a pool fire, a BLEVE, and a toxic gas release), is computed as once every 800 to 1500 years. Is this an acceptable or unacceptable risk to expose the residents of rail corridors to? Such a question cannot be assessed effectively without an understanding of the consequences of such incidents. The following two sections deal with both the physical range of impact and the specific effects of each of the seven hazard events if they were to occur in three selected areas in Toronto.

2.5 - IMPACT AND CONSEQUENCES BY INCIDENT TYPE

In the above discussion of seven types of hazardous incidents associated with railway accidents, a range of probabilities has been recorded to reflect hazard estimates on rail lines within the City of Toronto. As recorded in Table 2.9 these probabilities extend from a high of a probable incident every 800 years for a torch fire to a low of a probable incident every 160 000 years for a vapor cloud explosion. The corollary to probability estimation in providing a complete picture of public hazard is determining the extent of impact or consequences of the various hazardous incidents. By comparing both probable timing and consequences of incidents, it is possible to assess what form of incident would be acceptable to the public. This in turn can help the authorities to assess the necessity or justification of available alleviation measures.

---

* Each incident is expected to occur on the rail network in the City of Toronto once in the period shown.

The following discussion deals with the possible consequences of the seven incident categories in the circumstances of their occurring in typical locations along the rail lines within the City of Toronto.

Note: The hazard areas described below are obtained from Reference 2 in the End Notes and were developed by means of various hazard area models described in the above paper. These were computed by using data on rail operations in North America.

In Table 2.10 below, the term lethal zone refers to an area where an exposed person would be subject to life-threatening conditions. The radius listed would represent the extent of such a lethal zone in each case, representing the hazard distance from the damaged car. Another factor is related to the effect of a rail car moving laterally in a derailment. According to a recent US research report,[5] a statistically probable distance of removal from the track of a derailed car is about 40 ft (i.e. 50% of accidents were equal to or greater than 40 ft).

Accordingly, in relevant cases the lethal zone radius has been increased by 40 ft.

TABLE 2.10

EXTENT OF HAZARD AREA

Rail Hazard Incident Type	Lethal Zone Radius (feet)
Torch Fire	60
Pool Fire	600
Vapor Fire	1 180
Vapor Cloud Explosion	3 600
BLEVE	590
Toxic Gas Release	2 000

Source: Generating Hazardous Material Risk Profiles on Railroad Routes. Raj and Glickman, Transportation Research Board, 1985.

It can be noted that the above impact ranges are computed on the assumption of a full release of a tank car's contents. A release of partial contents has a higher probability but a correspondingly smaller area of impact. The above research is purported to reflect the effect of tank car retrofit on DC incidents.

2.6 - EXPECTED IMPACTS ON SELECTED CITY SITES

The following discussion deals with the impact or consequences of the above hazardous incidents upon specific locations within the City of Toronto. The following three sites have been selected for examination of accident impact in three representative rail corridor sections in Toronto.

1. Rosedale between Governor's Bridge and Mount Pleasant Road.
2. Galt/Weston Subdivisions, north of Queen Street.
3. The Union Station area.

Figure 2.5 shows these corridor sites in the Toronto area.

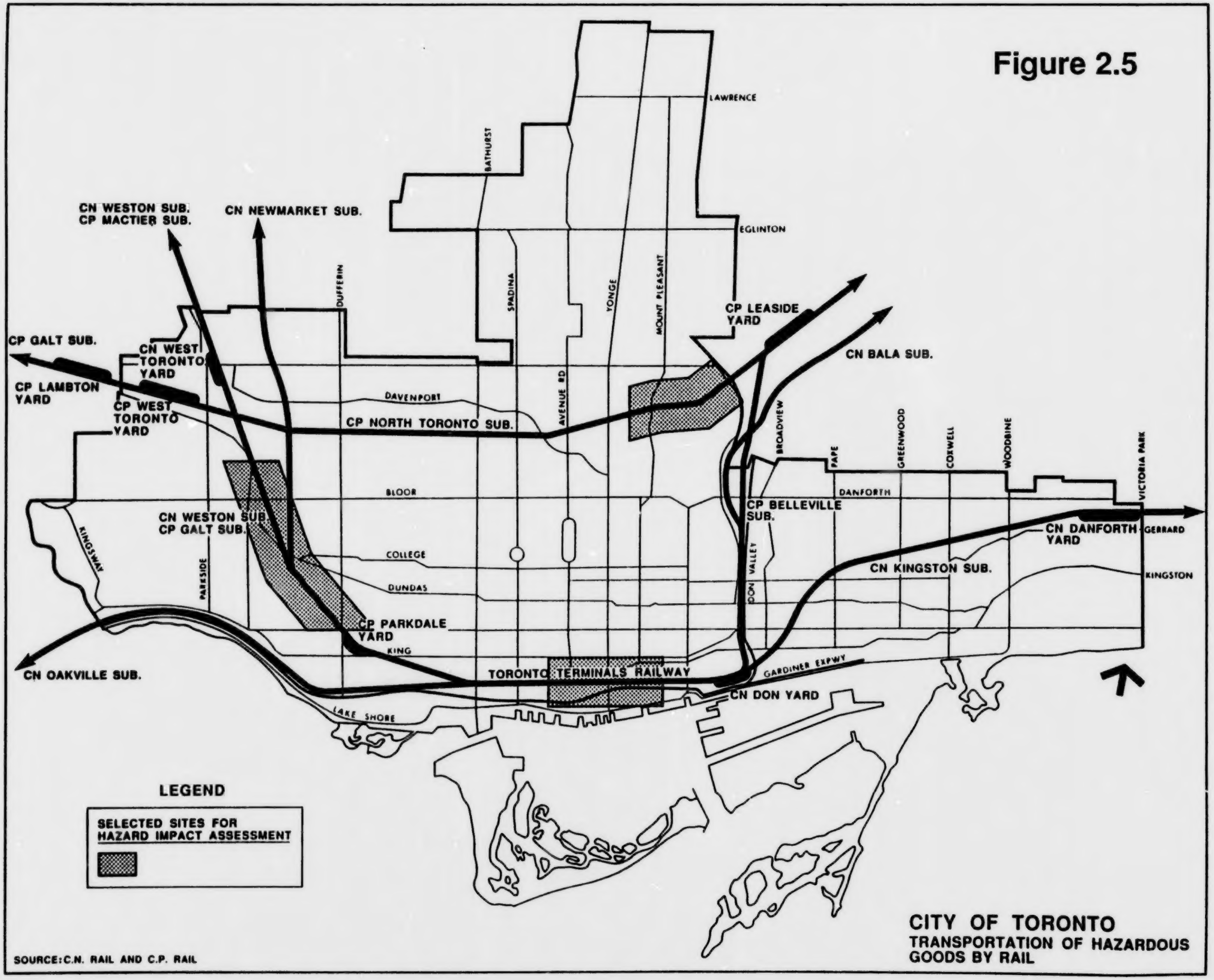
The information in this chapter is influenced by a recent paper dealing with the effect of urban topography upon the impact of rail incidents occurring in the Toronto area.[6] This paper makes the following comments about the effect of urban topography on accident impacts:

> "Release consequence analyses undertaken to predict the effects of failure of containment of propane storage and shipping vessels routinely assumed ideal conditions, i.e. flat terrain without nearby obstructions. In particular, such simplifications are usually made with heavy gas dispersion calculations.
>
> Topography of the release site not only influences the dispersion of heavy gases, but also directly affects the propagation of a flame front through a flammable vapor cloud mixture, the impact of thermal radiation and the trajectories of vessel fragments.
>
> Seldom are ideal topographical conditions encountered along propane tank car shipping routes. The Canadian prairies approximate such perfect conditions, but examination of previous accidents reveals that a large proportion of propane releases occurred near busy population centers."[6]

In the analysis carried out of hazard from rail accidents involving DCs, two corridors were defined which identified two spatial categories of hazard potential. These zones are referred to in the following discussion and are defined as follows.

High Consequence Zone (HCZ) The HCZ represents basically a 250 m distance from the railway tracks with adjustment for special topographical features where relevant (i.e. escarpments, catchment basins, ravines, etc). It represents essentially the extent of impact of the most probable and/or most destructive rail incident categories.

Figure 2.5


LAWRENCE
EGLINTON
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
DUFFERIN
CN WESTON SUB.
CP MACTIER SUB.
CN NEWMARKET SUB.
CP LEASIDE YARD
CN BALA SUB.
CP GALT SUB.
CN WEST TORONTO YARD
CP LAMBTON YARD
CP WEST TORONTO YARD
DAVENPORT
CP NORTH TORONTO SUB.
BROADVIEW
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
DANFORTH
BLOOR
CP BELLEVILLE SUB.
CN WESTON SUB.
CP GALT SUB.
KINGSWAY
CN DANFORTH YARD
GERRARD
COLLEGE
CN KINGSTON SUB.
KINGSTON
DUNDAS
PARKSIDE
DON VALLEY
CP PARKDALE YARD
KING
GARDINER EXPWY
CN OAKVILLE SUB.
TORONTO TERMINALS RAILWAY
CN DON YARD
LAKE SHORE
LEGEND
SELECTED SITES FOR HAZARD IMPACT ASSESSMENT

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

SOURCE: C.N. RAIL AND C.P. RAIL

Medium Consequence Zone (MCZ) The MCZ represents basically a 1000 m distance from the tracks with adjustments for special topographical features. This zone represents essentially the probable limit of significant impact of any type of DC accident. Figures 2.6 and 2.7 depict the extent of the HCZ and MCZ in Toronto. Table 2.11 provides statistics on demographic and other features within the HCZ and MCZ.

2.6.1 - Rosedale/Moore Park Area - North Toronto Subdivisiondivision

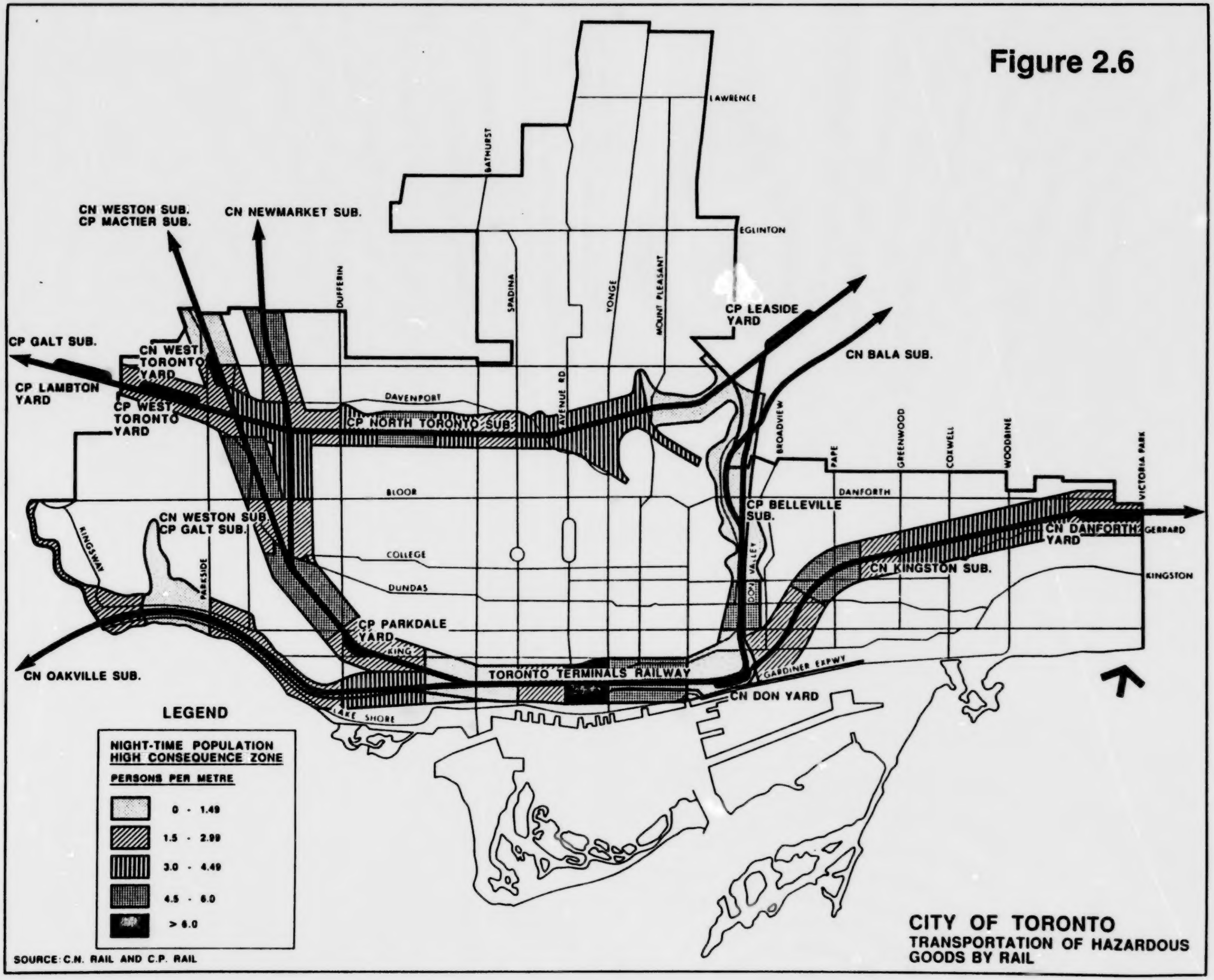
This is a residential area with a population of about 8000 located north and south of the CP North Toronto Subdivisiondivision, which has a very narrow right-of-way through this area. This line runs just south of the escarpment which provides a protective height of land to the Moore Park area north of the line. Population densities and road patterns would permit adequate evacuation of the HCZ, located largely south of the railway tracks. Both north and south areas are bordered by ravines which result in some constraints for evacuating the MCZ as a result of the limited number of entry points, i.e. Glen Road bridge, Roxborough Drive, Governor's Bridge, Whitehall Road, Moore Ave, Mount Pleasant Road north, St. Clair Ave. Housing largely consists of two-story residences on standard lots with considerable shrub and tree cover.

The rail right-of-way through this area is approximately 70 ft wide, indicating in many cases residential buildings within 50 ft of the tracks. It is estimated that the high consequence zone, approximately 500 m wide would contain:

resident population	- 2080 persons
daytime population	- 640 persons
nighttime population	- 1850 persons.

The total high and medium consequence zones for this stretch are estimated to contain:

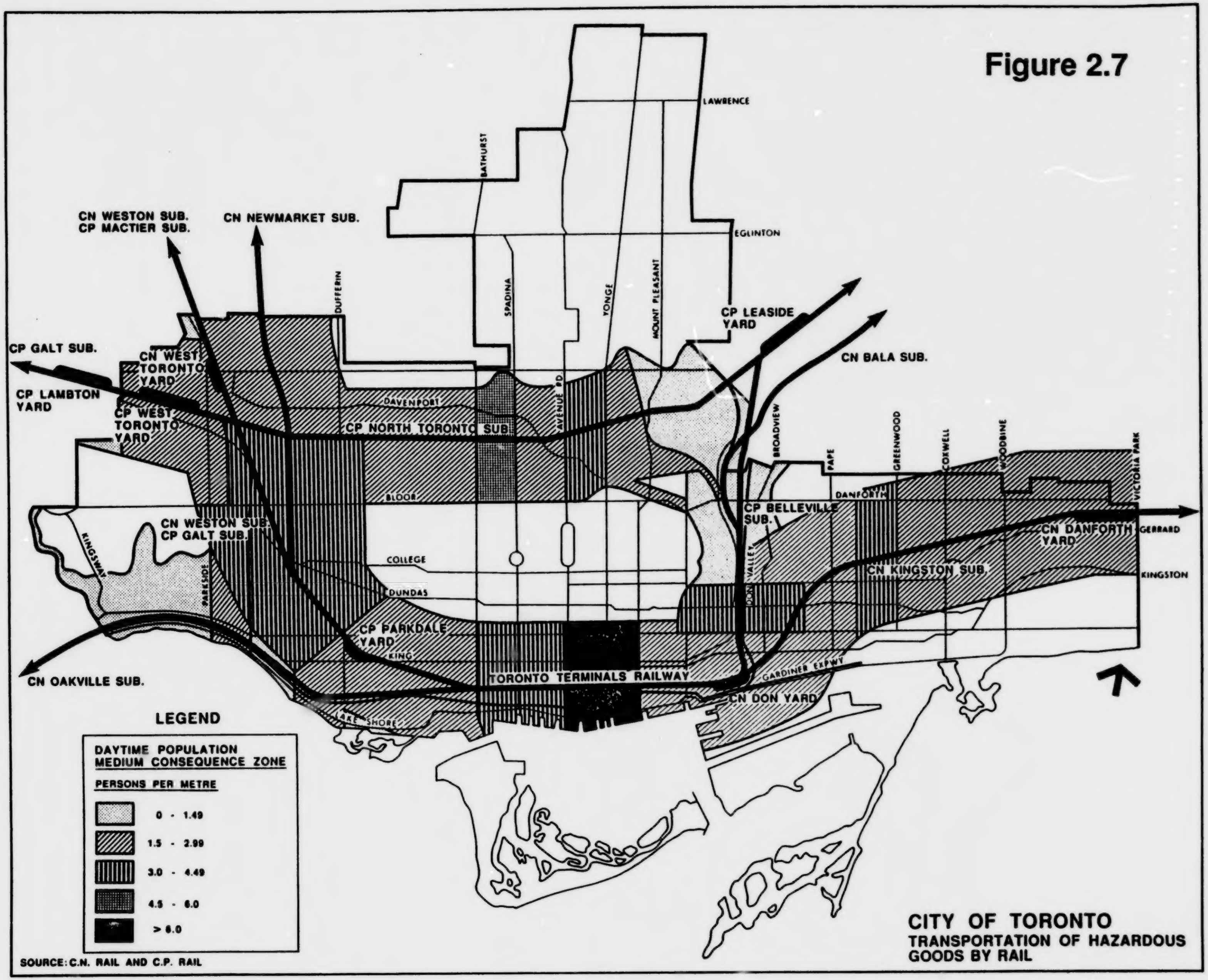
Figure 2.6


CN WESTON SUB.
CP MACTIER SUB.
CN NEWMARKET SUB.
CP GALT SUB.
CN WEST TORONTO YARD
CP LAMBTON YARD
CP WEST TORONTO YARD
CP NORTH TORONTO SUB.
CP LEASIDE YARD
CN BALA SUB.
CP BELLEVILLE SUB.
CN DANFORTH YARD
CN KINGSTON SUB.
CN WESTON SUB
CP GALT SUB.
CP PARKDALE YARD
TORONTO TERMINALS RAILWAY
CN DON YARD
CN OAKVILLE SUB.
LAWRENCE
EGLINTON
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
DUFFERIN
DAVENPORT
BLOOR
COLLEGE
DUNDAS
KING
LAKE SHORE
KINGSWAY
PARKSIDE
BROADVIEW
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
DANFORTH
GERRARD
KINGSTON
DON VALLEY
GARDINER EXPWY
LEGEND
NIGHT-TIME POPULATION HIGH CONSEQUENCE ZONE
PERSONS PER METRE
0 - 1.49
1.5 - 2.99
3.0 - 4.49
4.5 - 6.0
> 6.0

SOURCE: C.N. RAIL AND C.P. RAIL

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS
GOODS BY RAIL

Figure 2.7


CN WESTON SUB.
CP MACTIER SUB.
CN NEWMARKET SUB.
CP GALT SUB.
CN WEST TORONTO YARD
CP LAMBTON YARD
CP WEST TORONTO YARD
CN WESTON SUB.
CP GALT SUB.
CN OAKVILLE SUB.
CP PARKDALE YARD
CP NORTH TORONTO SUB.
TORONTO TERMINALS RAILWAY
CN DON YARD
CP LEASIDE YARD
CN BALA SUB.
CP BELLEVILLE SUB.
CN KINGSTON SUB.
CN DANFORTH YARD
LAWRENCE
EGLINTON
BATHURST
DUFFERIN
SPADINA
YONGE
MOUNT PLEASANT
AVENUE RD
DAVENPORT
BLOOR
COLLEGE
DUNDAS
KING
LAKE SHORE
KINGSWAY
PARKSIDE
DON VALLEY
BROADVIEW
PAPE
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
DANFORTH
GERRARD
KINGSTON
GARDINER EXPWY
LEGEND
DAYTIME POPULATION MEDIUM CONSEQUENCE ZONE
PERSONS PER METRE
0 - 1.49
1.5 - 2.99
3.0 - 4.49
4.5 - 6.0
> 6.0

SOURCE: C.N. RAIL AND C.P. RAIL

CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

TABLE 2.11

SUMMARY OF POPULATION, EMPLOYMENT AND TOPOGRAPHIC DATA FOR THE ACCIDENT CONSEQUENCE ZONES, BY RAILWAY SUBDIVISION

STATISTIC	ZONE	KINGSTON	BALA/ BELLEVILLE	OAKVILLE	NEW-MARKET	GALT/ WESTON/ MACTIER	GALT/ NORTH TORONTO	TTR	(TTR-2001)*	ALL SUBS.	PORTION IN YORK OR EAST YORK	CITY OF TORONTO	% OF CITY
POPULATION	-HCZ	21 363	4 102	7 222	13 884	20 213	31 333	4 657	(16 492)	97 427	(1 185)	606 247	15.9%
	-MCZ	93 322	32 455	38 958	63 304	111 581	122 244	15 959	(31 185)	338 783	(14 143)	606 247	53.5%
EMPLOYMENT	-HCZ	9 497	2 750	8 177	7 315	14 558	16 849	39 460	(75 129)	88 815	(900)	508 788	17.3%
	-MCZ	19 629	12 073	19 839	19 196	40 164	45 069	168 288	(213 613)	266 886	(1 973)	508 788	52.1%
SCHOOLS	-HCZ	4 329	0	0	2 238	3 944	7 252	420	(570)	9 681	n/a	97 326	9.9%
	-MCZ	20 255	5 865	3 234	14 615	16 395	22 001	2 182	(2 332)	56 130	n/a	97 326	56.1%
HOSPITALS/ NURSING HOMES	-HCZ	0	0	813	0	608	134	0	(0)	1 573	-	-	-
	-MCZ	1 135	784	2 052	48	1 364	1 258	697	(697)	5 364	-	-	-
OTHER SPECIAL POPULATIONS	-HCZ	0	0	0	0	0	5 333 (College)	0	(0)	5 333	-	-	-
	-MCZ	500 (Jail)	500 (Jail)	0	0	0	5 333	0	(0)	5 833	-	-	-
DAYTIME POPULATION	-HCZ	16 434	2 881	7 780	10 792	18 837	27 520	26 156	(51 080)	101 089	(896)	644 473	15.5%
	-MCZ	59 767	24 129	28 771	45 172	75 333	87 155	110 053	(141 316)	327 279	(5 427)	644 473	49.9%
NIGHTIME POPULATION	-HCZ	21 098	4 242	9 244	13 183	21 711	31 675	14 496	(32 682)	109 602	(1 247)	647 380	16.7%
	-MCZ	89 550	32 909	41 380	59 861	109 822	121 068	54 360	(76 838)	369 591	(13 172)	647 380	55.1%
SUBDIVISION LENGTH IN METRES		6 732m	4 332m	6 420m	4 152m	7 740m	10 512m	4 452m	-	44 340m	(768m)		
PERSONS PER METRE													
DAYTIME	-HCZ	2.44	0.67	1.21	2.60	2.44	2.66	5.88	(11.47)	2.50			
	-MCZ	8.87	5.69	4.48	10.87	9.73	8.48	24.72	(31.74)	9.75			
NIGHTIME	-HCZ	3.13	0.98	1.44	3.18	2.81	3.11	3.26	(7.34)	2.63			
	-MCZ	13.30	7.88	6.55	14.42	14.19	11.93	12.21	(17.25)	11.60			
TOPOGRAPHIC FEATURES BY PERCENT OF LENGTH													
CATCHMENT BASIN		10%	-	28%	-	-	53%	84%	-	26%			
PROTECTIVE ESCARPMENT		-	68%	57%	-	-	67%	-	-	31%			

* Projection based on Railway Lands Development Plan.

Source: Municipal records.

resident population	- 7940 persons
daytime population	- 2430 persons
nighttime population	- 7140 persons.

The population is divided between the areas separated by the rail corridor with about 40% to the north and 60% to the south. The northerly areas would be protected from the more confined hazards by the escarpment extending some 50 ft above the tracks, while the southern zone sits well below the railway embankment.

The likely effects of the various hazard incidents are discussed below reflecting the effect of an adjacent rail accident with rupture involving tank car or cars carrying propane or chlorine. The hazard areas discussed in Section 3 above assumed a relatively flat, unimpeded area and can be modified by the specific urban environs in the following descriptions.

(a) - Torch Fire

This constitutes a giant blow torch effect with typically a 20 foot flame which would not be expected to pose a serious threat to the adjacent community.

(b) - Pool Fire

It is expected that pool fires would be more serious in the lower temperatures experienced in winter as a result of the likely larger deposits of liquid occurring from a release. An unignited pool would be expected to disperse along the south side of the rail right-of-way and run along the north-south streets. Upon ignition this could affect an area larger than the standard given (i.e. 600 ft radius) because of fragmentation along the roads, affecting a resident population of up to 700 persons. The following comments indicate the expected events occurring after ignition:

> "Shielding afforded by housing, vegetation (different for winter and summer) and vehicles, influence the actual incident fluxes within each bounded area and hence the exposure time, the number of both injuries and fatalities and the amount of property damage. However, secondary fires will most likely erupt from cellulosic bearing shields (i.e. trees, fences, etc) less than 15 ft from the pool fire.
>
> Faced with the real situation, panic-stricken people will not think to shield themselves, but will try to move away from the fire as quickly as possible. Radient heat fluxes will strike their largely unexposed (clothed) backs. Under these circumstances, exposure time will increase but effective thermal fluxes will decrease with radial distance from the fire."[6]

The above reflects the conditions of a hazard scenario accompanying a pool fire. The high proximity and density of homes in this area would heighten exposure to the spreading conditions of a pool fire. Considerable injuries and property damage plus fatalities would be expected. Fire damage could extend to adjacent neighborhoods.

Nighttime populations would be higher but would be generally protected from the severe radiation temperatures of the initial ignition (with a very short burn duration) but would be exposed to expected subsequent burning of structures. Weekend daytime conditions in warm season could be hazardous considering the number of outdoor population and likely burning of trees and shrubbery.

(c) - Vapor Fire

A vapor or flash fire refers to the dispersion and ignition of a heavy gas cloud (e.g. propane). The extent of lethal zone under ideal conditions is estimated by Raj as an area of 0.38 km (1180 ft radius), an area four times the extent of the pool fire impact.

The implications of this form of incident is described as follows in the paper by Klement and Napier[6]:

> "Under ideal topographical conditions the discharged vapor would initially form into a hemispherical cloud and become more pancake-shaped as dispersion causes the diameter to increase.
>
> The movement of propane vapors to the north would be blocked by the escarpment. It is important to note that the mixture would be flammable up to the base of the hill.
>
> Dispersion to the south would be hindered by the obstacles present (houses and trees). The vapors would flow around these 'blocks' seeping into the basements of some houses and collecting in any depressions. The point concentrations of the cloud would be routinely changing from place to place as the material disperses through the residential area. Pockets of flammable mixtures would collect in several areas, possibly remaining there for a long time. Cloud movement to the south would be slow and restricted but not stopped. This is important to note when considering the time it would take for the area to be cleared of any vapor after the release.
>
> Dispersion would in general parallel the escarpment. Cloud movement would follow the railway corridor to the east and west. The cloud would become cigar shaped as it moved along the paths of least resistance. At the base of the hill the mixture would remain flammable for a long period as the cloud elongates and disperses at the edges to the east and west as well as to the south, although to a lesser degree. The cloud centre will not displace to any extent. Dispersion of the vapors would take a long time and would be greatly assisted by an east-west wind."6

Ignition could occur as a result of several causes:

- electrical discharge,
- friction sparks,
- hot surfaces,
- flames,
- hot gas jets.

The resulting conflagration would undoubtedly have a similar effect as a pool fire over a much larger area--possibly affecting up to 2000 of the resident population, and with endangering fires over half the area of the medium hazard zone.

(d) - Vapor Cloud Explosion

As a result of an LPG leak from a tank car, a freely dispersed vapor cloud can form. Under certain wind conditions this cloud could rise above houses and trees, otherwise it could infiltrate the adjacent neighborhoods. The hazard area of a 3600 ft radius, referred to in Section 2.5 above, is based upon an unconfined, windless condition. It could be expected that prevailing conditions in the subjected area would constrain the cloud one way or another, and the impact area could be one-third to one-half the standard of a 3600 ft radius. This might be expected to encompass a hazard area (lethal zone) of up to half the total area of the consequence zones. This in turn could affect some 2500 to 3500 of the resident population.

In the case of this type of accident, heat radiation would be the main cause of death and injury. Depending upon the season and time of day, many of these persons would be protected from radiation effects if indoors. In any event, it would be a disaster of significance proportions resulting in much death and destruction.

(e) - BLEVE

BLEVE is a term that has become notorious in the field of hazardous incidents over the past few years and the extent of their explosions have become familiar. Their probability, given a release, according to Raj and Glickman is over eight times as great as that of a Vapor Cloud Explosions, but is still a highly improbable event. The BLEVE explosion creates a fireball at ground level which rises slowly into the sky. As with a Vapor Cloud Explosion, a BLEVE would have severe impacts at the higher levels. For example, according to Klement and Napier the radiant heat flux at the top of the escarpment would be at life-threatening levels and therefore the escarpment would not have the protecting effect as in the case of low level events (e.g. pool or vapor fires). It should be noted that two elementary schools are located above and in close proximity to the escarpment. Raj and Glickman indicate a hazard area similar to that of a pool fire, thereby threatening a resident population of about 700. BLEVE burn duration is estimated at 12 seconds, a long period for high burning flux (temperature) levels.

(f) - Release of Toxic Gas

For the calculations of impacted area, the release of a chlorine-filled tank car following a shell or head puncture is assumed. Since chlorine is a highly toxic gas, a lethal hazard area of 1.2 km^2 (2000 ft radius) is estimated by Raj and Glickman. The same conditions of distribution would be expected as described above for a vapor fire. With the constraints of the escarpment and the Mount Pleasant ravine, the bulk of the discharged gas would be expected to extend throughout much of both the high and medium consequence zones, thus threatening up to 4700 persons in the resident population. It should be noted that vehicles with internal combustion engines will not operate in clouds of gas other than oxygen.

(It should be noted that the corridor area adjacent to Yonge St. and westerly are located in a catchment basin and are highly susceptible to a toxic gas release.)

In general, the above description of the dispersion and impacts of released hazardous liquids or gases according to various hazard events will apply to most adjacent sites in Toronto. The following discussions will deal with special conditions not previously covered.

2.6.2 - Area between Queen and Dupont Streets adjacent to Weston (CN) and Galt (CP) Subdivisions

This is a flat area with essentially no significant topographic features. There is a varied mix of commercial and industrial land uses along the high consequence zone. There is also a large number of schools (18) in the hazard zones between Queen and Dupont/Annette Streets. There are a number of high-rise apartments and shopping centers located in the high consequence zone. Most of the residential areas consist of single family homes with high occupancy levels.

Population densities in this area of the City are high as indicated in the following table (covering consequence zones between Queen and Dupont/Annette Streets).

High Consequence Zone

Residential population	-	15 518
Daytime population	-	11 110
Nighttime population	-	15 054
Employment population	-	5 440

Medium and High Consequence Zone

Residential population	-	86 970
Daytime population	-	50 917
Nighttime population	-	82 684
Employment population	-	21 511

A dense network of local streets feeds into the collectors and arterial routes. In some areas, particularly in the High Consequence Zone, the local street patterns are somewhat scrambled with resulting evacuation difficulties expected. This area includes portions of the Junction Triangle with its concentration of industries using hazardous and noxious commodities. The TTC Bloor subway passes across this corridor with a station located within the HCZ.

Railway rights-of-way along this corridor range from 160 to 200 ft in width. This is a heavily traveled stretch of track with some five main lines along this section and many sidings and industrial spurs, particularly on the east side of the line which carries both heavy through and transfer freight traffic.

The significance of this corridor in relation to hazard incident types is discussed as follows.
Torch Fires could be hazardous to the intensive land uses immediately adjacent to the railway, i.e.

- high-rise apartments,
- shopping centers,
- small industry, schools.

Pool Fires could impact the above-mentioned immediately adjacent uses plus residential neighborhoods in some cases. Pool fires could threaten up to 1200 residents plus elementary and high schools in some locations. As well, the various non-residential land uses located in the High Consequence Zone would be threatened in a pool fire

Apartment houses on the west side of the Galt/Weston corridor at the Parkdale Yard.

Looking north-west on Galt/Weston corridor. Industry, apartments on right-of-way.

Looking west along Galt subdivision into West Toronto Yard.
Example of check rails over the Runnymede underpass.

High school at right-of-way of Newmarket subdivision.
Looking north from Dundas Street.

(variegated industrial, shopping centers, office buildings). A fast-developing pool fire could have a devastating effect along this corridor under some circumstances, particularly under conditions of constrained evacuation which might occur in rush hours or winter conditions.

Vapor Fire would have some similarities to a pool fire but with a greater dispersion. A vapor fire could include in its lethal zone over 3000 of the resident population. It would impact all of the land uses discussed above with a widespread, expanding fire hazard throughout the residential neighborhoods in the corridor.

Vapor Cloud Explosion, BLEVE Fireball Effect. These infrequent incidents would have a devastating effect over this corridor affecting many thousands in the lethal zones. The high-rise apartment areas would be particularly vulnerable to these incidents.

Toxic Gas Release would be expected to affect the housing neighborhoods, and industrial and shopping areas. Up to 20 000 residents and 7000 employees could be affected by the lethal zone of a toxic release. Under adverse wind conditions this could cause considerable confusion and resulting casualties. This release would have the most impact on single and two-story residential, industrial and shopping buildings. Nighttime populations would be vulnerable.

Level Crossings. In national rail accidents, level crossing accidents always represent a major accident category, particularly involving fatalities and injuries. Fortunately, there are in the City only three level crossings--one on the North Toronto subdivision and two on the Galt/Weston corridor. In our opinion, only one of these constitutes a significant hazard. This is the Strachan Avenue crossing on the Galt/Weston corridor. In our opinion the coexistence of three circumstance indicate a potentially hazardous situation:

- relatively high DC/SDC flows in this corridor which includes numerous yard switching movements at this location,
- heavy mixed automotive traffic on Strathan Avenue with a variety of heavy trucks,
- imminent approval for a multiple use development at this site (the Massey Ferguson property development).

In our judgment a heavily used level crossing on this busy rail corridor, combined with DC/SDC traffic, industrial sites, and a major multiple-use development property all in the vicinity of each other, represents a special hazard situation, and likely justifies a grade separation at this site, which would, however, represent a a difficult and costly undertaking.

2.6.3 - The Downtown Area

This is, of course, the location of the largest concentration of population in the Metropolitan Toronto area in the form of a daytime employment population of 148 000 employees (within the hazard zones HCZ, MCZ--Simcoe St. to Jarvis St.). The routes passing through the Toronto Terminal Railway area carry the smallest volumes of dangerous commodities of all the mainlines in the Toronto area. Accordingly, accident probabilities (and consequently release or incident probabilities) would likely be minimal.

The revised rail corridor proposals as part of the Railway Lands development plan include a relocated CN "High Line" bypassing Union Station immediately to the south. Any DC rail incidents would threaten most severely the proposed dense accumulation of office towers in the financial district extension proposed for the CP lands immediately south of the High Line. The high towers of the present downtown area would be partly screened by existing buildings on the rail right-of-way. It is also possible that toxic gases could seep into the Union Station complex. Dangers could exist in both the case of existing buildings and the proposed development structures.

The two most hazardous types of incident affecting this area are

- an LPG release and explosion (BLEVE or vapor cloud fire or explosion),

- a toxic gas release.

In the case of LPG explosion (e.g. BLEVE) it is likely that the blast impact and heat radiation would be absorbed by the immediate buildings and would not impact the total area. The initial blast would shatter windows in the adjacent high-rise towers, and the subsequent burning phase at a high level (estimated at 230 ft above the ground by Klement and Napier) would inflict injury and fire devastation to the exposed offices and apartments.

Vapor clouds would be confined and not susceptible to massive explosions. There could be seepages into buildings followed by sub-explosions in these buildings. The overall impact of LPG-type explosions would be to some degree locally confined but devastating, and could affect thousands of downtown workers and residents.

A toxic gas release would be particularly threatening. Starting at Union Station and extending as far north as the Toronto City Hall there is an extensive walkway system which can accommodate several thousand persons at any given time. It also feeds into many high-rise complexes along the corridor. A feature of this system is a highly efficient air circulation system. A typical rail tank car carries up to 90 tons of toxic gas (e.g. chlorine which is heavier than air). If even a small portion of the contents of such a tank escaped into this walkway, the effect could be devastating. There would be no way to either evacuate or shut down the air circulation systems before extensive injury or death occurred. (The escape of LPG liquid or vapor into this system could have a more localized but equally threatening effect.)

It might be concluded from the above gloomy scenarios respecting the devastating effects of LPG and toxic gas accidents in the Toronto Terminal Railway section in downtown Toronto, that a prohibition of the transport of these commodities through this area would be warranted.

2.7 - EVACUATION

An important factor in developing a hazard profile on corridor vulnerability to rail DC accidents is the facility of population evacuation afforded by adjacent corridor conditions. The assessment of evacuation needs is a complex subject reflecting the following elements:

Type and conditions of DC incidents. The literature is featured by references to incidents which build up rapidly in minutes following an accident. In the case of toxic gas spills (e.g. chlorine, anhydrous ammonia), following a release these can spread by prevailing winds through the adjacent community with little delay. As well, LPG releases in a rail accident are often accompanied by the ignition of the released gas. In many such cases, adjacent residents may encounter difficulty in evacuating safely. Conversely, kinetic LPG incidents (e.g. BLEVE) can be expected to occur after a delay, in most cases, of over 30 minutes (assuming no loss or damage of tank car insulation).

Population diversity and density. In many areas of Toronto, high population concentrations occur immediately adjacent to the rail right-of-way in a variety of modes--single family or high-rise residential, industries, shopping areas, schools, hospitals, etc.

Corridor building types and street patterns. Buildings occur in all forms. High density, high-rise close to the right-of-way represent an extreme exposure level. Local streets perpendicular to the rail rights-of-way afford greater ease of evacuation than the case of streets parallel to the rail line.

Topography and weather conditions. Heavier-than-air gases and hazardous liquids will run down into catchment basins or ravines, while escarpments provide protection. Winds can disperse substances favorably or unfavorably, while temperature or precipitation can influence the form and ease of dispersion.

High Consequence Zones. The definition of the high consequence zones for the assessment of link hazards was based both upon the impact area of the most probable DC incidents, and the area of most devastating impact of other less probable incidents. This led to the selection of an area about 500 m wide centred on the tracks, adjusted where necessary for topography. A similar area was considered by the National Transportation Safety Board in research for retrofit design of tank cars. Specifically, a 30-minute evacuation period was recognized as desirable for such a zone in selecting design criteria for thermal insulation layers (specifications covered a range of 30 to 100 minutes for deferral of BLEVE occurrence). Accordingly, a 30-minute period can be considered as a target for evacuating the High Consequence Zones along the Toronto rail subdivisions.

In considering the facility of evacuation along these sections, a range of factors are evident:

- Speed of public communication following the accident.

- Population mobility ranging from highly mobile individuals to various levels of ambulatory disability.

- Street patterns and possible congestion from incident traffic conditions.

In most cases the HCZ to each side of the track is 250 m wide. As a result, by excluding the rail right-of-way, and in some cases adjacent industrial land uses, a resident will require only a fairly short trip to evacuate the HCZ. It can be assumed that in the case of single family homes and convenient street patterns, little difficulty would be expected in moving out within 30 minutes, with the majority moving by foot plus a number of disabled or young moving by car. In our opinion, traffic capacity would not be expected to be a main factor in HCZ evacuation.

This study has examined in general terms. conditions for population evacuation along the rail subdivisions within the City of Toronto, with special attention paid to those subdivisions carrying relatively heavy flows of DCs and SDCs, i.e. the North Toronto, Galt and Mactier subdivision. This review indicates conditions of population evacuation in the above subdivisions as follows:

- **North Toronto Subdivision**

  The street pattern which includes frequent north-south streets, generally favors ready evacuation of the HCZ.

  A special case exists between Balfour Park and Davenport where congested residential or parallel streets close to the railway right-of-way, create apparent problems in evacuating a large HCZ in a catchment basin south of the line.

  Other HCZ features in specific locations could present potential problems:

  - two subway entrances, TTC headquarters on Bathurst Street,
  - high population concentrations,
  - schools,
  - senior citizen residences (e.g. Lambert Lodge),
  - industries,
  - strip shopping areas.

  Overall evacuation adequacy with some problem areas.

- **Galt Subdivision, Queen St. to Dupont St.**

This corridor presents some problem features within the HCZ as follows:

- high-rise apartments,
- high population densities,
- industries,
- shopping centres,
- schools,
- Junction triangle (hemmed in by railway lines).

In some areas mixed land uses, street complexities and barriers could cause difficulties.
Areas of inadequate evacuation conditions.

- **Galt Subdivision (west to City limit)**

Difficulties within HCZ, i.e.
- high population densities,
- parallel residential streets,
- built-up, commercial arterial within HCZ.

Generally inadequate evacuation conditions

- **Mactier Subdivision (north to City Limit)**

Difficulties within HCZ:

- parallel residential streets,
- population concentrations,
- industries,
- jumbled land uses,
- hemmed-in by railways.

Areas of inadequate evacuation conditions.

Medium Consequence Zones. As defined on page 102, the MCZ represents basically a 2000 m corridor centred on the tracks with adjustments for topography. This zone is based upon the probable maximum limit of impact of the more extensive DC incidents--e.g. toxic gas releases, vapor cloud explosions, BLEVE rocketing.

In most cases these represent the most improbable hazardous events and, as in the case of Mississauga, evacuation will be carried out as a safety precaution. Accordingly, for practicality reasons, a longer evacuation time period can be used. In the absence of any known standard, 60 minutes is proposed.

In assessing MCZ evacuation facility, the subject of traffic movement and street capacity is a consideration. Organization and the rapid mobilization of emergency forces would be necessary to effect an efficient evacuation. In a general assessment of the relatively high DC traffic corridors, the following comments are made.

In the case of the North Toronto subdivision and the westerly extension of the Galt subdivision, assuming effective organization, no serious problems in evacuating the MCZ could be expected, at the same time noting the special problems referred to in discussing the HCZ evacuation.

In the case of the Galt/Weston and Mactier/Weston corridors, the high population and employment densities, and the complex street patterns, evacuation difficulties could possibly occur, and special measures (i.e. extra staff, linguists, special traffic control measures) would likely be required to effect an efficient evacuation.

It should be mentioned in connection with the downtown business area of Toronto, that although DC flows are very low, the great difficulties in evacuating this area, either the HCZ or MCZ, makes the banning of the transport of certain SDCs through this area a consideration.

2.8 - HAZARD PROFILE

As referred to in Section 2.1.3 this study has carried out an assessment of each rail subdivision link in the City of Toronto.

In this process the nine basic subdivision corridors (combining CN/CP characteristics where these share the corridor) were divided into some 47 links. Each link was selected as representing essential uniform conditions or characteristics throughout its length. It should be noted that four out of nine members of the Study Advisory Committee participated along with consultant personnel in carrying out this assessment.

Procedure and methods are outlined in Appendix D. The purpose of this exercise is to quantify and assess those factors that could affect the occurrence of incidents and the likely extent of their impact upon the adjacent corridor. These data were plotted geographically for each link in relation to the high and medium consequence zones.

As shown in Appendix D, three basic working forms were used in this assessment.

1. Map of Land Use and Topographic Features

These consist of the official City land use and street map at a scale of 1:10 000, and indicating the high and moderate consequence zones. Where relevant, topographic features are referred to.

2. Hazard Assessment Data Table

This map plus table depicts the railway facilities along the corridor, showing such features as: main lines, branch lines, yards, sidings, crossovers, level crossings, side streets, etc. Link boundaries are shown and recorded for each link are the following factors:

- DC, SDC and total carload volumes
- total gross tons carried
- persons per metre track length (daytime and nighttime) by HCZ and MCZ
- school enrollment (by HCZ and MCZ)
- hospital beds (by HCZ and MCZ)
- Percent zoned residential (by HCZ and MCZ)
- topographic features (i.e. catchment basins, protective escarpments)
- vulnerable features (exposed schools, hospitals, high capacity transportation facilities, etc).

3. Map of Population and Employment

This map at 1:10 000 outlines the HCZ and MCZ and records for subzones the following data:

- resident population
- employment
- daytime population
- nighttime population.

An additional source of relevant data is shown on Table 2.12. This indicates a calculated estimate of accident probability for each subdivision.

The operative factor on Table 2.12 is the expected frequency of train derailments involving dangerous commodities (i.e. damaged and/or derailed car containing DC) on the sections in question. The estimated value for the total network within the City of Toronto is once every 60 to 90 years, while the frequency according to individual subdivision ranges from once every 180 to 250 years for the North Toronto subdivision to once every 2300 to 4100 years on the Weston subdivision.

In reviewing the various input elements of the hazard factor assessment, Table 2.13 has been prepared which evaluates in a generalized

TABLE 2.12

EXPECTED FREQUENCY OF TRAIN DERAILMENTS ON THE RAIL SYSTEM WITHIN THE CITY OF TORONTO WHICH INVOLVE DANGEROUS COMMODITIES**

Subdivision	100% Probability of an Accident every X years, for all DC and SDC
CN Kingston	1 200 to 1 900
CN Bala	2 000 to 2 400
CP Belleville	1 100 to 1 500
CN Bala/CP Belleville	700 to 900
CN Oakville	1 600 to 3 200
CN Newmarket	350 to 800
CP Mactier	700 to 850
CP Galt (to Union Station)	350 to 500*
CN Weston	2 300 to 4 100
CP Mactier/CN Weston	500 to 700
CP Galt (Union)/CN Weston/CN Newmarket	200 to 325*
CP Galt (West Tor. Diamond-Lambton)	400 to 500
CP North Toronto	180 to 250
Overall rail network	60 to 90*

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* This figure includes operational statistics relating to a discontinued symbol train previously run out of the Parkdale Yard. Present figures would be likely to indicate a lower probability.

** Car containing DC involved in train derailment, release may or may not occur.

Source: CP Rail - Submission to Federal Task Force, May 1986.
CN Rail - Submission to Federal Task Force (data revised October 21, 1986).

TABLE 2.13

HAZARD PROFILE MATRIX

	SUBDIVISIONS							
HAZARD FACTORS	Galt W. Toronto to Lambton	Medler/Weston	Galt/Weston	Oakville	Kingston	Bala/Belleville	North Toronto	Newmarket
1. Accident Probability	Relatively high.	Relatively high.	Moderately high.	Relatively low.	Relatively low.	Relatively low.	Relatively high.	Relatively low.
2. DC/SDC Traffic, Line Features	High DC/SDC volumes. 3 through lines, 2 major yards, intense line activity.	High DC/SDC volumes. 3 main lines, intense rail activity.	High DC, moderate SDC volumes. 4-5 main lines, numerous sidings, switches, etc, wide right-of-way.	Moderate DC/SDC volumes. Heavy train traffic, 4 main lines, yard sidings, etc wide right-of-way.	Low DC/SDC volumes. Extra track, switches, etc, generally wide right-of-way	Moderate DC/SDC volumes., Sharp curve, some sidings, etc, alongside roadways.	High DC/SDC volumes. 2 main lines with few extra tracks.	Low DC, no SDC volumes. 1 through line, numerous sidings, spurs, switches, narrow right-of-way.
3. Topography	No features.	No features.	No features.	Catchment basin.	Catchment basin.	In Don River flood plain, protective escarpment.	Protective escarpment, catchment basins.	No features.
4. Land Use, Vulnerable Features	Mainly industry north of line, residential retail south of line, hospitals, schools.	Mostly industrial, in HC2 some exposed residential in junction triangle, large retail in HC2.	Many schools, institutions, shopping, hospitals, industries in HC2, varied land uses. TTC subway line.	Gardiner Expressway in HC2, much open space south of line, hospital in HC2, low residential, major recreation sites.	Dense residential. LPG storage, ravine crossings, elevated rail sections, schools in HC2, seniors in HC2.	Don Valley Parkway and Gardiner Expressway in HC2, bridges, overpasses, open space.	Rail vertical displacement, narrow right-of-way, retail, schools in HC2. Two TTC subway lines.	Numerous land uses in HC2, i.e., schools, industry, shopping, Bloor subway.
5. Population Factors	High population south of line. Total daytime and nighttime population high.	Low residential population in HC2. High daytime and nighttime population in HC2.	High daytime and nighttime populations.	Low population in HC2, dense population in HC2. North of line, high $ residential. No population south of line.	High daytime and nighttime population.	Little residential population in HC2 (nighttime). Considerable daytime population in HC2.	Fairly dense residential. High nighttime population.	Heavy population. Employment, schools and hospitals along line, junction triangle area.
6. Evacuation Conditions	High density sites in HC2 (especially hospital).	Some industry, retail problems.	Some potential problems. Street patterns, densities, etc.	Gardiner Expressway closure impede service vehicle access, recreational population exposed.	Some industries and institutions in HC2 plus high rise and retail.	High capacity facilities subject to closure, otherwise few problems.	Generally adequate with problem areas.	Some possible problems.
7. Overall Assessment	High area of concern. Population and hospital exposure.	High area of concern. High population exposure.	Generally moderate level of concern. Densifying land uses potential problem.	Generally low to moderate level of concern with low DC/SDC traffic. Some potential evacuation problems.	Low area of concern with present low DC/SDC volumes.	Some environmental threat. Low to moderate area of concern with present low DC/SDC levels with some potential threats.	Generally high level of concern.	Low area of concern at present levels of DC/SDC traffic.

fashion the overall attributes of the subdivision corridors with respect to DC incident hazard and the corridor vulnerability to such incidents if and when they occur.

The consequences of incidents involving transported DCs is a spatial phenomenon. The extent to which such accidents as toxic gas releases and LPG ignitions or explosions impact on the adjacent community depends solely upon the physical conditions associated with the incident and its environment. The hazard profile analysis is an attempt to assess the spatial characteristics (i.e. community densities, topography, housing and street patterns, etc), and their affect upon community vulnerability.

In Table 2.13 three subdivision corridors are indicated as demonstrating relatively high levels of concern: (See Figure 2.8.)

- North Toronto subdivision
- Galt (West Toronto to Lambton) subdivision
- Mactier/Weston subdivision corridor.

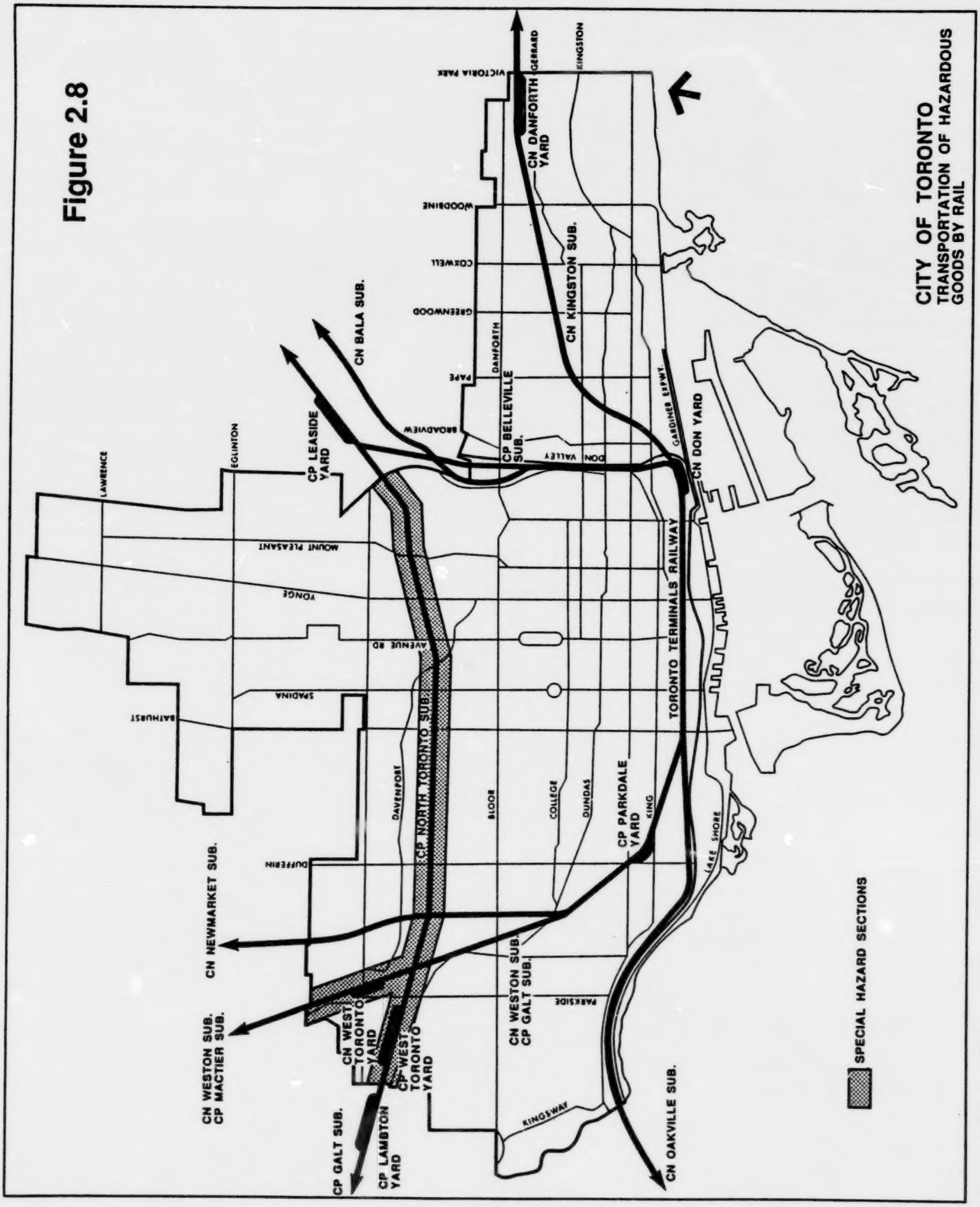
The Galt/Weston subdivision corridor demonstrates a moderate level of concern.

Four subdivision corridors demonstrate a low or low to moderate level of concern:

- Newmarket subdivision
- Oakville subdivision
- Kingston subdivision
- Bala/Belleville subdivision corridor.

Note: These results are highly dependent on DC/SDC traffic levels, and any future changes in these volumes could drastically revise the overall assessment or rating.

Figure 2.8



CITY OF TORONTO
TRANSPORTATION OF HAZARDOUS GOODS BY RAIL

▨ SPECIAL HAZARD SECTIONS

LAWRENCE
EGLINTON
CP LEASIDE YARD
CN BALA SUB.
BATHURST
SPADINA
AVENUE RD
YONGE
MOUNT PLEASANT
BROADVIEW
PAPE
DANFORTH
GREENWOOD
COXWELL
WOODBINE
VICTORIA PARK
GERRARD
KINGSTON
CN DANFORTH YARD
CN KINGSTON SUB.
CP BELLEVILLE SUB.
DON VALLEY
GARDINER EXPWY.
CN DON YARD
TORONTO TERMINALS RAILWAY
CP NORTH TORONTO SUB.
DAVENPORT
BLOOR
COLLEGE
DUNDAS
KING
CP PARKDALE YARD
LAKE SHORE
DUFFERIN
CN NEWMARKET SUB.
CN WESTON SUB.
CP MACTIER SUB.
CN WEST TORONTO YARD
CP WEST TORONTO YARD
CN WESTON SUB.
CP GALT SUB.
PARKSIDE
CN OAKVILLE SUB.
KINGSWAY
CP GALT SUB.
CP LAMBTON YARD

Conclusion

These results indicate that those subdivisions having heavy DC/SDC volumes and relatively high incident probability demonstrate significant conditions of vulnerability to the effects of DC incidents. Accordingly, it can be recommended that these Hazard Profile assessments be used as a basis for assigning priorities for implementing relative levels of investment and effort in accident alleviation measures. That is, those sections with high levels of concern can justify the highest levels of risk management practice. This concept will be followed in preparing recommendations in this report, and those three subdivisions demonstrating relatively high hazard conditions will be referred to as special hazard sections .

2.9 - OVERALL ASSESSMENT OF HAZARD

The above discussion is directed toward an examination of the following attributes of hazards associated with the transport by rail of dangerous commodities:

- the characteristics of likely hazardous events,
- the probability of occurrence of such events in the City of Toronto,
- the impact and consequences of such events particularly as they relate to prevailing conditions along the rail corridors in Toronto.

The purpose of this review has been to interpret in a meaningful way the unique conditions of rail services and its specific hazards. Probabilities can be computed for individual incident types, or estimated to represent the combined probability of one of a variety of possible events. The latter provides a measure of overall public hazard possible from a whole family of events. Looking at individual events, three hazard types stand out as having significance for safety in Toronto as a result of the combined effect of both their probability and scale if impact. These include:

Release of Toxic Gases. These appear to stand out as having particular relevance for rail safety in Toronto. There are a number of Special Dangerous Commodities in the poisonous or corrosive gas categories, that are regularly transported in the Toronto area (e.g. chlorine, anhydrous ammonia, sodium chlorate). A toxic gas spill could be the single most risky event for the public associated with rail transport of dangerous commodities. This type of accident represents a serious danger to the various residential and population concentrations along the rail corridors in Toronto.

Pool Fire. Although the speed and extent of impact is less than that of a toxic gas spill, the probability of a pool fire is relatively high (0.29) following an LPG release. The area of hazard of a pool fire is about one-eighth that of a chlorine spill, however, a fire incident has additional hazards beyond those of a toxic spill--property damage, potential spread of fire, etc. Pool fires represent a localized but devastating impact if occurring in any of the many residential or population concentrations along rail corridors in Toronto.

BLEVE. These have a low probability compared with the above two cases. They are the most common of the LPG-spill explosive incident nd produce high heat radiation from a location several hundred feet above the surrounding community, thus representing a potential threat in areas of population concentrations.

The above three significant hazard incidents are associated with the transport of toxic gases and liquid petroleum gases by rail. These two special dangerous commodity types are commonly transported by rail lines operating in Toronto, as shown on Table 2.4.

In assessing the strategic relevance of this subject and the most appropriate action to be followed by the authorities, we are faced with two perceptions of reality. One the one hand, increasingly we see a perception articulated by public groups (i.e. MTRAC, ratepayer groups, aldermen) of a threat of serious hazard to large groups of population. On the other hand, the railways appear to be doing as much as possible to prevent accidents on these lines, and point to the very low incident of DC accidents as evidence of rail safety. Which position is right--both, either or neither? The key question facing the authorities is whether there is a clear and definite public danger that justifies further, more effective, relief measures, or whether the situation constitutes an insignificant level of risk in comparison with those dangers that most citizens routinely face.

How serious is the danger? It is safe to assume that the public perceptions are more influenced by what they see as reality, rather than by statistical estimates of accident probability. What is seen as reality is twofold:

- the obvious number of trains carrying large numbers of freight cars through built-up areas in Toronto,
- the media reports on occurrence of multiple-car accidents on rail lines across the continent.

Conversely, the railways have implemented numerous measures to optimize operating safety on their various subdivisions (see Chapter 1), and their safety record in the Toronto area has been excellent. Nevertheless, regardless of the extent of safety measures, the element of unpredictable and uncontrollable factors remain - human error, unexpected mechanical failure, external interventions (vehicular traffic, vandalism, etc).

The foregoing review of rail DC incidents indicates very low probabilities. The combined hazard of three of the most threatening incidents (i.e. pool fire, toxic gas release, and BLEVE) represent a higher order of hazard. In assessing the significance of public danger associated with the above prospects, two other factors need consideration--uncertainty and concentration of hazard.

Uncertainty. The picture of the likely nature and scale of rail DC accidents in Toronto is characterized by uncertainty. That is uncertainty of:

- future levels and patterns of DC traffic,
- operating elements (container design, effect of trespassers),
- corridor elements (evacuation problems, DC storage).

These present a picture of uncertain conditions prevailing in the future.

Concentration. By the combined nature of rail service and corridor conditions it turns out that those rain links having the highest flows of DC shipments also represent the heaviest concentrations of daytime and nighttime populations as well as the greatest vulnerability to the effects of DC incidents.

* * * * * *

In our opinion, the above attributes of concentration and uncertainty, as well as the high exposure levels indicate a potential risk level that public officials should take note of and ensure that:

- a prioritizing of risk management measures be considered,
- careful consideration be made of appropriate action to maximize public safety.

Major Findings and Conclusions

- Heaviest SDC volumes and highest incident probabilities are on the North Toronto subdivision, the Galt subdivision at west Toronto, and the Mactier subdivision.
- The highest consequence zone is the Toronto Terminal Railways.
- The three most commonly transported DCs on the North Toronto subdivision are:

	Percent of DC Traffic	Type of Substance
Propane	24%	compressed flammable gas
Styrene	8%	flammable liquid
Methanol	8%	flammable, poisonous liquid.

- No obvious patterns or trends in shipments of DCs or SDCs on Toronto rail lines.
- Approximately 80% of DC and SDC traffic on Toronto lines are trips through Toronto CMA.
- 53.5% of City of Toronto population are located within hazard zones of railway lines.
- 20.2% of City of Toronto population within Galt/North subdivision corridor (major transport corridor of SDCs).
- Three types of DC incident pose the main hazard to Toronto population from rail accidents (pool fires, BLEVEs and toxic gas release).
- The probability of these occurring in Toronto is very low.
- The impact of such accidents could threaten hundreds of people.

- Rail accident potential in Toronto is characterized by uncertainty of patterns and numbers, and by operational or corridor characteristics.

- The DC rail hazard is featured by the concentration of population and the vulnerability to accident effects along the corridors with the heaviest DC/SDC traffic.

CHAPTER 3

WHAT CAN BE DONE?

In the previous chapter, 'How Present a Danger', it is concluded that although the railways operating in Toronto do so at high levels of operating safety, a large proportion of the City's population could be exposed to the effects of DC accidents occurring on rail lines. It is also concluded that regardless of the expected probability of occurrence of hazardous incidents (approximately once every 800 to 1500 years for any one of three key incident types) the uncertainty and concentration of hazard potential makes it imperative to develop an effective risk management program for rail services in Toronto.

Risk Management Objectives

In developing a public position concerning the transport of hazardous goods by rail, the following objectives are proposed as criteria for selecting safety measures.

1. To manage the transport of dangerous commodities so as to optimize public safety in general (i.e. where possible to minimize or eliminate the impact of a serious incident by means of a variety of risk management measures).

2. In achieving Objective No. 1, to minimize, where possible, the hazardous exposure of the public to dangerous commodity transport (i.e. to remove them from proximity to each other).

3. Since rail is the safest available mode of land transport, to avoid diverting freight from rail to truck transport.

4. To sustain the competitive efficiency of rail freight operators in this area.

5. To enhance the performance of industrial and commercial enterprises in Toronto.

6. To avoid transferring the transport of dangerous commodities from Toronto so as to introduce a threat to other communities.

7. To achieve a cost-effective solution in terms of total benefits and costs.

8. To achieve a solution compatible with the social, physical, and service environment of the adjacent community.

In addition to such objectives, an important concern is the recognition of public safety needs as a major element in any public or corporate decision making. The public authorities must become conversant with the specific needs for the transport of DCs in built-up areas and ensure that these needs are satisfied in any future developments or operational changes.

In this chapter, in order to address the above objectives, it was decided that a range of possible alleviation measures could best be discussed according to the following three categories of possible measures.

A. To enhance the safety of existing rail operations. (Section 3.1)

B. To minimize the public impact of existing operations. (Section 3.2)

C. To reduce the amount of dangerous goods traffic through Toronto. (Section 3.3)

These form an extensive and complex subject. The purpose of the following discussion is to identify the scope of possible measures and to outline their relevant characteristics and possible ramifications for Toronto, and finally to provide an overall assessment of the measures considered.

3.1 - MEASURES TO ENHANCE THE SAFETY OF EXISTING RAIL OPERATIONS

As described earlier, (see Section 1.3) much has been done in recent years by both the regulatory authorities and the railways to improve the safety of rail operations. In the Toronto area there has been a heavy emphasis on operational and equipment safety improvements. These, in most cases, impose either a cost burden and/or an operational constraint upon the railway carrier. A question to be considered is whether a more balanced approach to safety is to be preferred. That is, to include measures that both mitigate the community impact of rail operations, and reduce DC traffic within the City.

Initially we will review feasible means of enhancing the safety of existing operations. This covers:

- extent of compliance with measures under RTC order,
- acknowledging voluntary measures,
- reviewing additional measures.

3.1.1 - Origin and Nature of RTC Orders

Railway plant, equipment and operations have undergone change which may appear slow but is quite impressive considering the great length of the railway network, the vast size of the railway and the freight car fleets which have access to it, and the long cycle for replacement of heavy, durable rolling stock compared to highway trucks. By 1979, when the accident at Mississauga occurred, progress had been made in substituting roller for plain bearings, in detecting 'hot boxes' on moving cars, and in other respects, although the benefits were still diffuse. The Mississauga incident and ensuing Inquiry drew attention to the special needs of urban areas and the problem of dangerous commodity traffic. The result was to accelerate particular improvement programs and to add new ones. Subsequent accidents have added their quotas of new or strengthened provisions.

The Railway Transport Committee of the Canadian Transport Commission took the measures recommended by the Grange Commission of Inquiry (into the accident at Mississauga), held Show Cause Hearings in 1981 to determine their likely effect on railways, shippers and other parties, and during 1981-82 issued a series of orders requiring changes to rolling stock and operating practice in urban areas, with a timetable for implementation. These requirements coincided with regulations issued under the Transportation of Dangerous Goods Act of 1980 (affecting all modes of transport), and by a revised version of the CTC 'Red Book' - Regulations for the Transportation of Dangerous Goods by Rail. These orders have been described in Chapter 1, pp 19 to 22.

Later orders specified that tank cars carrying specific commodities should not be rolled free during sorting, and that coupling at either end should be controlled and gentle. Humping of explosives and poison gases was prohibited. Meanwhile targets were set for equipping railway car fleets with roller bearings to reduce the risk of derailment, and for modifying tank cars to guard against release of contents in the event of derailment or collision.

Finally, the RTC ordered prescribed mechanical inspections of all cars at specified intervals and points of interchange with other railways and of cars loaded with dangerous commodities close to their points of origin.

These requirements were not as stringent in every respect as those recommended by the Grange Commission. Notably, speed limits were less restrictive, and more time was allowed for modifying cars. Nor was a limit placed on the length of trains carrying dangerous commodities.

Progress with each component of this program is examined below.

3.1.2 - Compliance with RTC Orders

(a) - Upgrading of Rolling Stock

Appendix B contains further information on the nature and effectiveness of these retrofits.

(i) Roller Bearings

A 'hot box' on any car poses a hazard to all cars on a train. The RTC has ordered that 75% of the railways' revenue car fleets be equipped with roller bearings by the end of 1987. CN and CP Rail have reported 65% and 64% compliance to date respectively and are confident in meeting the target.

The target for tank cars specifically is not clear, but CP reported that 75% of the DCs it hauls and 90% of the SDCs, are on roller bearings.

In addition, roller bearings don't eliminate journal failures entirely. Failure is less frequent, but it follows a different and possibly more rapid burn-off rate (presently under study at the National Research Council).

(ii) Double-shelf Couplers

Since February 28, 1985, no tank car carrying a regulated commodity can be accepted for transport by a Canadian railway unless equipped with double-shelf couplers, which are designed to prevent overrides. There is no recorded failure of a double-shelf coupler in this function in a Canadian accident.

(iii) Tank Car Head Shields

From December 31, 1981, it has been necessary for any designated tank car carrying a dangerous commodity to have full head shields, designed to resist puncturing.

(iv) Thermal Protection

From December 31, 1982, thermal protection or insulation has been necessary before such cars will be accepted for transport. This apparently has been successful in greatly increasing the time available for emergency measures, in the case of impinging fire.

(v) Bottom Fitting Protection

By January 1, 1989, all tank cars carrying dangerous commodities in Canada and the US are scheduled to have bottom fitting protection. (This modification is designed to prevent drain valves and the like from being sheared off during an accident.) This later scheduling results from the classification of DCs carried on such cars as less hazardous as other substances.

(b) - Operating Precautions

(i) Switching

The requirement since January 28, 1982 that designated tank cars be carefully coupled has led to no occurrence of a switching mishap (other than the MacMillan Yard accident of February 1984). Occasional rough couplings are still possible, given the nature of switching, especially if the yard is crowded and visual sighting is difficult. In the case of SDC cars in hump yards, flat switching is now an accepted practice (that is, such cars will not be allowed to roll free down a humping slope with a resulting possibility of excessive coupling speed and impact).

(ii) Marshalling of Loads

The RTC requires that buffer cars be placed between certain incompatible dangerous commodities to prevent their mixing in the case of an accident, and between any dangerous loads and the ends of the train. As verified on a recent field trip study, participants were able to verify the use of computerized methods for ensuring compliance with marshalling regulations. Five non-DC cars constitute the minimum buffer.

(iii) Documentation

The Committee had the opportunity to examine the range of documents generated for a shipment of dangerous goods, and to note the type of information available on short notice at several points in the event of emergency. Both railways have the computer capability for producing hard copy of data on DCs under transport, plus characteristics and handling practice in an emergency. Federal regulations are covered by both the transportation of Dangerous Goods Regulations Part 4 and the CTC

Regulations for the Transportation of Dangerous Commodities by Rail. These require full documentation of dangerous goods shipments, including shipping documents, waybill, consist, and emergency response forms plus instructions for providing these to local emergency forces.

(iv) Operating Speeds

Symbol freight trains are assigned sufficient locomotive power to attain 50 mph where authorized. Higher speeds increase risk of derailment if track or equipment defects are present. In the CP record of over-the-road train derailments in 1984 and 1985, equipment causes began to appear only above 25 mph. More importantly perhaps, the number of cars derailed increased with the speed at derailment.*

Nevertheless, there comes a point when further reductions in speed gain little added safety and interfere excessively with efficient operations, with wide-ranging economic implications. Rail links work best at certain optimal speeds, depending on signalling, brakings, grades, traffic levels, length of haul, length of train etc. It perhaps should be the objective of public policy to increase the pressure for making a reasonable working speed as safe as possible, rather than using low speed in place of reliable engineering refinement.

In summary, rail line speed restraints can adversely affect rail operations in the following ways:

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* Other sources on the speed/cause of accident correlation include Item 1 in the End Notes plus research by Ecology and Environment, Inc., Buffalo, N.Y. and presented in notes by F.B. Silvestro, Vice-President (U.S. data).

- interfere with effectiveness of 'just in time' rail service to industry,

- likely increased need for rolling stock and manpower,

- diminish scheduling flexibility to permit optimizing train interconnecting opportunities,

- Perhaps generate demand for additional track miles by lowering capacity of heavily trafficked lines.

Another factor concerning speed restrictions is its affects on noise and vibration. A recent study commissioned by the City of Toronto* provided evidence on the subject of the noise and vibration effects of rail operations as follows:

- there is a slight decrease in noise levels with decreasing speed,

- that earthborne vibration levels are generally imperceptible beyond 20 meters from the tracks.

Railway representatives state that conditions vary with changing operations, i.e.

- that operating at lower speeds on heavily travelled sections such as the North Toronto subdivision, could cause lower gear settings and frequency ranges thereby causing increased noise and vibration levels,

- that lower speeds would create longer exposure to sound levels,

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* Noise and Vibration Study - CPR Line - Wards 5 and 10, Department of Public Works, City of Toronto, November 26, 1985.

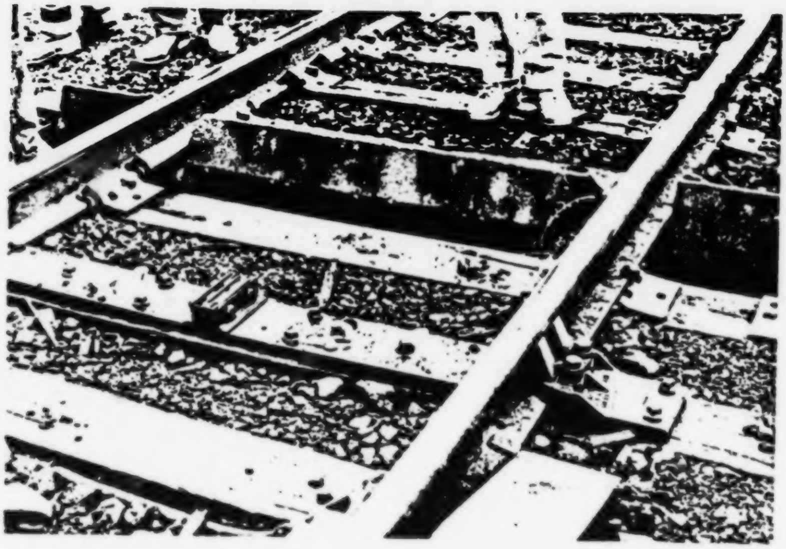
- that in the areas of transition between speed limits, increased noise and vibration would be caused by acceleration or deceleration.

The RTC orders arising out of the Show Cause Hearing specified that where designated inspections were not carried out, trains were restricted to 15 mph in built-up areas. This implicitly recognized the safety advantages of speed reductions. As a gesture of good faith CP Rail has adopted voluntarily a speed reduction to 25 mph of trains containing SDCs on the North Toronto subdivisions. This is a temporary measure subject to review by the Federal Task Force. We endorse this step and recommend that any proposed speed restrictions be applied to the special hazard sections, and other sections, where relevant.

(v) Prior Detection of Equipment Faults

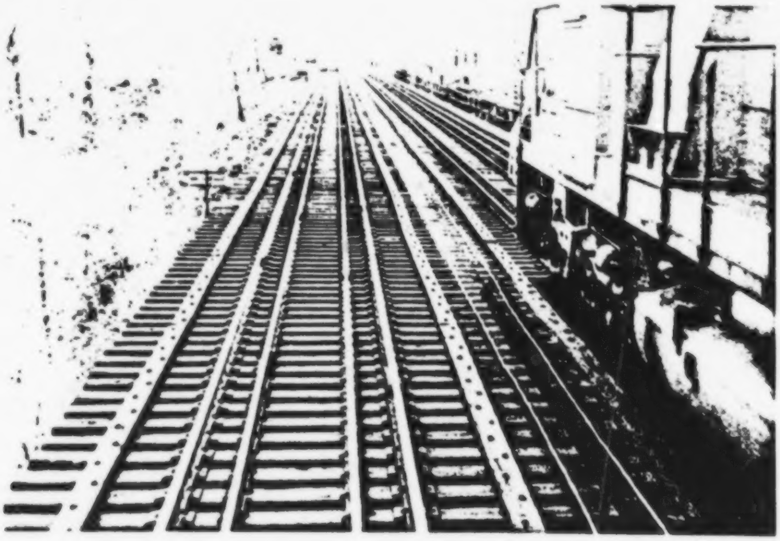
To meet RTC requirements for safety inspections, the two main railways chose to install lineside detectors on the main lines, rather than conduct visual pull-by inspections. There is now equipment at 11 locations within or close to the Toronto CMA. When evidence of overheated bearings occurs, an inspection is auto-matically carried out. Nationally, derailments due to journal failures were cut by half between 1981 and 1983. This improvement presumably can be credited to timely warnings by detectors and a growing proportion of roller bearings in the fleet. However, journal failures have levelled off at between 25 and 30 a year, with roller-bearing failures now predominating, reflecting the increasing preponderance of roller bearings in service.

The other tasks of lineside detectors are to 'sense' defective wheels and defective or dragging brake equipment. Derailments



Dragging Equipment Detector

This spring-loaded flange is designed to be knocked down by loose draft gear, chains, and other equipment, setting off an alarm monitored by the trackside computer.



Jordan Guard Rails - Railway Bridge

Within each pair of tracks a smaller pair of tracks is intended to deter derailments by confining wheel sets within the main rails, thus preventing derailments on the bridge itself.

Hot Wheel Detector

Placed at an angle enabling it to 'see' each wheel rim, this infra-red monitor measures the temperature of the wheel as it contacts the track and relays this data to a nearby computer for analysis.

Trackside Detection Station

The computer equipment inside this hut analyzes and displays the specific data gathered by the various detection sites. The type and location of defects is identified and displayed on an overhead signal board.

from these causes have not decreased nationwide, although the numbers are small.

(vi) Empties (Tank Cars last containing DCs)

Tank cars which last contained DCs have been a source of controversy recently, largely due to incidents in the CP Winnipeg Yard (1983) and the CN MacMillan Yard, Vaughan Township (1984). Certain parties (i.e. M-TRAC) have recommnended that these tank cars be handled in a fashion similar to loaded tank cars, a proposal that has not been agreed to by CN or CP, nor acted upon by the RTC.

Properly speaking, few DC tank cars are ever really empty; a certain percentage of the load remains in the tank. As a result, the terminology 'tank cars which last contained DCs' is more appropriate than 'empty.' To be called 'empty' a tank car must be fully purged of all contents.

The issues surrounding tank cars which last contained DCs are complex, and little research has been done on their characteristics. Opinion and pragmatic experience seem to be the basis for most decisions. Recent comments by Mr. C.H. Batten, Chief of the Hazardous Materials and Pipeline Accident Investigation Division of the NTSB, are relevant and are summarized as follows.

In the US, 'Empty' placards can be placed only on tank cars which contain a volume of substance less than 4.5% of the tank's rated water capacity. Mr. Batten indicated that this requirement is difficult for railways to monitor and, as a result, is apparently not often complied with in the US. Canadian railways have begun to differentiate between purged 'empty' cars and unloaded tank cars which last contained DCs. The latter can, however, still be placarded as 'empty.'

Tank cars which last contained DCs perform differently in accidents than do loaded cars. Any release, due entirely to the much smaller volume of DC carried, will be shorter in duration and will affect a smaller area. A fire-induced rupture may occur much earlier than it would with a loaded car, due to the reduced 'heat sink' provided by the DC and the concomitantly larger 'unwetted' area of the tank itself. The resulting explosion would, however, be much reduced in severity due to the small volume of DC involved.

Tank cars which last contained DCs can (like any light or empty rail car) pose a train handling problem if marshalled incorrectly between strings of heavy loaded cars. On undulating terrain this can, if combined with several other factors, pose a derailment risk.

In Mr. Batten's opinion, tank cars which last contained DCs, when under the 4.5% limit, can be humped and should not be subject to any marshalling restrictisons not already imposed on any other light or empty rail cars. As noted above, no research exists to corroborate such opinions. Cars which have not been kpurged, but still retain a residue of a DC load should be placarded. (A motion to placard tank cars which last contained DCs with 'residue' rather than 'empty' has been accepted in principle by US and Canadian authorities.)

The final word has probably not yet been heard on this subject.

It is essential that the RTC, as the regulatory body in charge, carry out investigations to establish whether or not special safety measures and/or placarding are required for tank cars which last contained DCs.

(vi) Conclusions on the Effect of RTC Orders

The improvements ordered by the RTC from 1981 have been implemented. It is expected that they have improved safety in the particular conditions of the Toronto rail network, although accidents there have been too few to establish if a shift has taken place, and of what degree and kind. National statistics can be applied with reservations however, and suggest the need for continuing review of bearings, switching and speed.

(c) - Monitoring and Surveillance

In addition to the retrofitting program imposed by the RTC, following the Show Cause Hearing in 1981, the RTC issued a number of orders which were outlined in Chapter 2, pp 19 to 22, covering inspections, speed restrictions, and switching and marshalling regulations. The implementation of such operating restrictions is more demanding than that of retrofitting equipment since it requires ongoing surveillance of operations.

The above measures were, of course, introduced as safety measures for the protection of concentrated populations along rail corridors. In the case of Toronto where a large proportion of the city's population could be threatened by major rail accidents, it is imperative that the necessary monitoring of these orders be carried out.

Effective implementation requires both monitoring of compliance and in the case of noncompliance, meaningful penalties. This study's scope has been interpreted to cover the need for effective surveillance in the Toronto area. The former RTC Chairman, John Magee, in his report on the Inquiry into the MacMillan Yard accident of February 28, 1984, covered this subject extensively (see 'RTC Staffing for Safety,' page 96 of his report). On page 101, paragraph 4, he states:

> "What can be said at the present time is that, making an educated guess, noncompliance is in the range of 5% to 25% in respect of various of the regulated activities. Levels of compliance fluctuate from region to region, depending on circumstances and conditions within each region."

The question is whether noncompliance in the Toronto area is at the 5% or 25% level. Certainly it would be expected that in heavily trafficked areas such as Toronto, effective surveillance would be more demanding than in quiet sections.

According to Mr. Magee the goal is to have an effective inspection of 5% of 200 000 cars annually. If SDC empty tank cars are included, this raises the total to 300 000. Mr. Magee stated at that time that the existing strength of inspectors was insufficient to carry out inspections on 10 000 cars annually (5% of 200 000). Even less if 300 000 cars is the target.* A target of 10% has been suggested as more appropriate. (It should be noted that 'gateway' inspections are to detect potential accidents--hot boxes or dragging equipment, while the inspections referred to by Magee are fairly comprehensive staff examinations.) Mr. Magee at the time of his report (December 1984) stated that 19 inspectors were needed across the country. About two or three of these would be allocated to the Toronto area. This need still exists with no additional designation of man-years by Treasury Board having been made.

In conclusion, the evidence indicates that even the target levels of the CTC for surveillance in the Toronto area are not being met. Surveillance is a measure that can be implemented more easily and cheaply than virtually any other step, and should be stressed in any action requested by Council to the federal authorities concerning the optimizing of rail safety in this area. Specifically, the RTC should be pressed to urge Treasury Board to approve the allocation of additional inspectors to this area.

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* It should be noted that the carriers (CN and CP) have responsibility for inspection for operating and maintenance purposes. The role of the RTC is to carry out sample inspections for compliance monitoring.

3.1.3 - Voluntary Safety Improvements

It should be noted that the movement toward significant upgrading of rolling stock and rail operating safety preceded the Mississauga derailment. As a result of major chemical incidents on US rail networks, research into tank car design led to the major retrofit moves of the late 70s. Since US and Canadian systems are interconnected in many ways, the effect of this spilled over the border some time before the RTC orders of 1981. Canadian railways were taking many steps already recognized as needed to ensure safe operating standards including retrofitting rolling stock, installing roller bearings, installing hot box detectors on rail lines and heavy track sections as in the case of the CP North Toronto subdivision.

3.1.4 - Other Measures for Consideration

Because of high concentrations of population and employment in the City of Toronto, measures beyond those ordered by the RTC might lend further assurance against accident and eventually perhaps permit relaxation of the present severe speed restrictions.

(a) - Yards and the Local Distribution Network

According to the Burton/Post report, in a six-month period in 1982 more than 600 dangerous loads were transshipped at points in the City of Toronto. In 1985 only 66 such shipments were recorded.

Characteristically, inbound dangerous commodities consigned by rail to the Toronto area proceed to final unloading points in a series of intermittent movements, involving various combinations of main and secondary lines, sorting yards, service tracks and finally industrial spurs. The most common form of accident in yard and distribution service is collision, although damage tends to be minor.

Presence of many dangerous commodity loads in a yard, especially overnight, could form a potential hazard, in the event of a conflagration in establishments adjoining the yard. Ready access to rail records of commodities stored in yards by municipal emergency forces is important. Special permits from the RTC are needed if cars are to be stored or held for extended periods on railway property.

While unloading on a private siding, a dangerous commodity car is technically off the rail system. The municipality will wish to be assured that any spillage is prevented from entering the public sewer system, as it did in Timmins recently with potentially serious consequences. Discussions with the province may be warranted to establish clearly the limits of respective jurisdictions and control.

In summary, attention is needed to ensure effective information is available and liaison maintained between railway and local emergency forces to ensure effective response to emergencies.

(b) - Running Lines

On running lines in Canada, the main type of accident has been derailment. Causes were track, equipment and operations related, in that order. Derailments due to track defects have taken place usually at low and medium speeds, with those due to equipment defects occurring at higher speeds.

Running track in the City of Toronto is now of the heaviest rail section, except for the lightly-used subdivisions of Newmarket, Bala and Belleville. On the heavily-used east-west lines, track rail has lasted about 25 years on CN's Kingston subdivision, which carries 15 million gross tons annually on two tracks (mainly passenger trains of moderate axle loading). By contrast, CP's North Toronto subdivision at 40 million gross tons, exclusively freight with axle loads up to 33 tons has lasted about 15 years. Following track re-laying on these two subdivisions in recent years, east-west running track is now continuous welded rail on closely spaced ties and crushed slag ballast. Old-style bolted rail joints were a cause of both rail fracture and car roll, due to rail-end battering and wear. On a positive note, much of the main-line rail in Toronto is at the beginning of its 15 to 25-year life cycle.

It is not generally appreciated that rail track is inherently flexible and that the limited vertical movement observable under passing wheel loads is neither unusual nor dangerous. Indeed, without this resilience there would be more rail fractures.

As referred to in Chapter 2, security on running lines is an ongoing problem. More intensive measures can possibly be justified on special hazard sections.

(c) - Rolling Stock

- Containers are likely to play a bigger part in the movement of dangerous commodities. There is a need to ensure that they are strong enough to operate in the railway environment, in particular to survive derailments, resist tampering in yards, and so forth. Authorities having jurisdiction should be urged to review appropriate regulations and revise when required.

- Although roller bearings are safer than friction bearings, in that they incur fewer journal failures per million car-miles than plain bearings, heating and breakup in the event of a component failing may be more rapid.

- Tank cars with armored head shields are still relatively vulnerable to side punctures; consideration might be given to fitting a rubbing strake at the widest part (i.e. special reinforcement to resist breaching).

To conclude, the most critical question appears to be the discrepancy in standards between tanktainers and tank cars. The authorities should satisfy themselves that this does not represent a potential danger.

(d) - Operations

Movement of trains on main running lines is directed by a Toronto area dispatcher for each company, using Centralized Traffic Control. The settings of power-operated switches and the indications displayed by color-light signals are controlled remotely. Track circuits sense and report the presence of trains and prevent conflicting movements being authorized. Each track is signalled for running in either direction, and crossovers at intervals facilitate overtaking movements when needed. The whole is supplemented by radio communication.

Although the signal system is fail-safe, and although there are devices in locomotive cabs to monitor the vigilance of the engineer, the possibility remains that he could misread or ignore a prior warning signal or the final stop indication, resulting in a collision with a train ahead or a derailment at a turnout from inappropriate speed. That is, the final decision is the engineer's. Technology is available which will bring a train to a halt, independently of the engineer, safely before a stop indication. The tragic Hinton, Alberta accident demonstrates that human error can negate mechanical systems.

An accident to be feared on double-track lines is a DC train going in one direction being struck by a derailed car or shifted load on a train going in the other direction. The closing speed being the sum of the opposing train' speeds, destructive forces can be high. For consideration is a 'one-train-only' rule within city limits when a designated SDC train is passing through. Such a measure could be considered in a high-hazard zone.

The RTC chose not to order a restriction on the length of trains carrying dangerous commodities. The Grange Commission had recommended 4 000 ft, unless all cars, DC or not, had roller bearings. The reason given by Justice Grange was to permit visual checks by crewmen on the whole of the train. There are several curves on the main lines in the City of Toronto where even 4 000 ft would be too long to keep under continuous surveillance. The move to cabooseless trains would virtually eliminate sighting as an aid to hot box detection. We have to assume that this subject is being thoroughly ventilated in proceedings regarding caboose elimination, and we can only stress that sight lines are more restricted in an urban environment where the effects of journal failure are more serious for the public. As well, recent research* indicates the possibility that longer trains can increase both the probability and the severity of an accident.

Experience shows us that no system is fail safe. In the conditions of hazard potential found in Toronto, the authorities should take every opportunity to improve safety, including Advanced Train Control Systems, train length restrictions and so on.

Advanced Train Control Systems are in various stages of R&D in Europe and North America. These techniques present the opportunity to apply advanced technology to obtain more automated train operations thereby achieving more economical, efficient and safer rail performance. Some of the components include:

- high tech communications equipment for both data interchange, and overriding operating control,
- up-to-date computer intelligence systems for problem solving and operations controls,
- on-track transponders to permit automatic vehicle location,
- the system, in emergency situations will override the human control to avoid detected accident possibilities.

ACTS is currently in the R and D stage and no on-line permanent application is expected for several years. Nevertheless, the nature of Canadian railways organization will make it possible to effectively implement such an automated system and thereby achieve high performance safety.

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* Item 1 in End Notes plus F.B. Silvestro, Vice-President, Ecology and Environment, Inc., Buffalo, N.Y.

(e) - Administration

The unique attribute of rail systems is the sovereignty or exclusiveness of rights-of-way which is owned by a specific carrier with the effect that no other competing carrier can operate without submitting to external control and compensation. A model for integrated operation is provided by the Toronto Terminal Railways which for a distance of about three route-miles through Union Station is owned jointly by the two major railways and operated by a separate organization.

An earlier area-wide application was considered by provincial authorities to aid in the GO Transit operation. It was suggested that the joint-use arrangement be extended across the Toronto commuter shed. By opening up new routes for the trains of each company on the lines of the other, proponents argue that interference between freight and commuter trains could be relieved. The same routing flexibility presumably could be exploited to reduce the threat of hazardous goods in transit past particular communities. Such ideas were not considered worthy of further action in the passenger mode. Certainly the extension of such an arrangement over such a wide area would entail prolonged and complex discussions with rail companies with extensive consideration of operating arrangements and compensation. Such an arrangement would appear to challenge the essential basis of individual rail carrier operations and competitiveness.

Would an extended TTR system (covering the rail network in and around Metropolitan Toronto) provide opportunities for enhancing public safety in respect to rail service? In the case of the City of Toronto 'box' network, there would appear to be few potential benefits, since there is already a specialization and separation of rail operations; primarily passenger on CN, primarily freight on CP east-west lines within Toronto; and there is an effective system of interconnecting rail traffic between the two systems.

The main advantage of the integrated approach (TTR-style) would appear to apply to the rerouting or relocating of through rail traffic (see Section 3.3 below). In the case where advantage was seen for a protected by-pass corridor carrying through traffic of both carriers, an integrated approach could be investigated into joint ownership of right-of-way (possibly involving other parties--e.g. governments), and joint operation by the two carriers on an equitable basis.

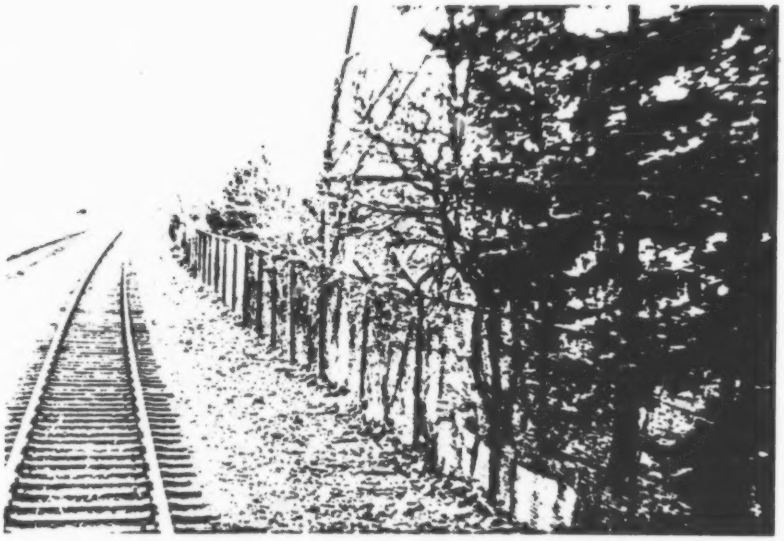
(f) - Availability of Rail Operating Data.

With the increasing proliferation and transport of dangerous chemicals, the demand for data on the transport and storage of such materials also increases. Three types of use of such data can be contemplated:

- emergency measures data,
- planning/policy reviews,
- research studies.

Emergency Measures Data. The primary need here is in the instance of an accident or release to have ready access to information on the type and amount of dangerous and other commodities involved in the incident, either actively or passively. This includes both materials being transported and those stored in the vicinity of the mishap.

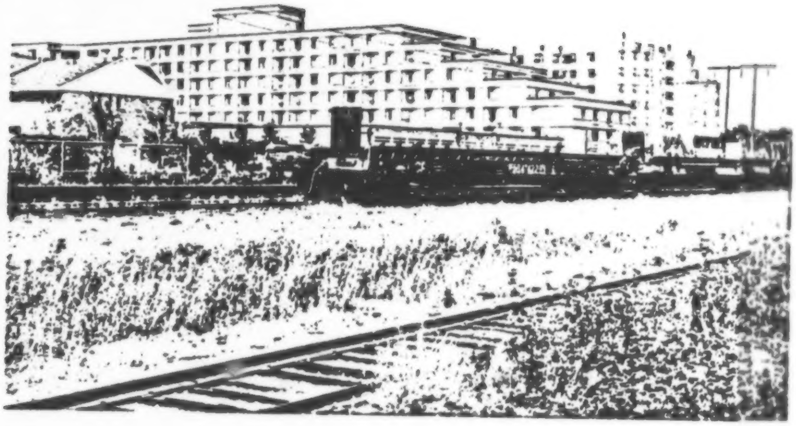
- Transported Materials. Needs here include both consist material identification and detailed information on material characteristics and emergency handling guidelines. In the first instance, the train consist list should be available with



Right-of-Way Security

This photo shows the top of the line in right-of-way protection. Few sections are protected by this quality of fencing.

This section of the Galt/Weston corridor illustrates the farm-type fencing mandatory on rail rights-of-way.



Lambert Lodge

Looking east along North Toronto subdivision at Christie Street.

Dupont Street near Symington Street, located in high consequence zone of North Toronto subdivision.

the conductor at the rear of the train and in the locomotive cab with the engineer (i.e. CN engineer does not have full consist). Where such sources are obliterated, a copy can be obtained from the carrier either by on-line computer transfer, by telecopier or by telephone. The City Fire Department is equipped to receive this information through their HAZMAT vehicle. The City Fire Department is part of the Metropolitan Toronto Emergency Planning Advisory Committee (MTEPAC) and its resources are available for use at MTEPAC command headquarters during an emergency.

In the case of material characteristics, etc, the federal CANUTEC data system is available for use. The Fire Department's HAZMAT vehicle has access to CANUTEC which can be used by MTEPAC in an emergency. The City of Toronto Fire Department has a data base which complements the CANUTEC source, and has the ability for computer data transfer with other sources (such as carriers, manufacturers, shippers, etc). As well, it is proposed to install telecopying and cellular telephone equipment on the Hazmat vehicle, thus providing ready access to telephone data sources. A CANUTEC connection exists at Police Headquarters on 590 Jarvis Street, for use by MTEPAC in an emergency.

Fire Department officials have sought electronic access to railway records on DCs in transport. Such access was not approved because of need for marketing security. The Federal Transportation of Dangerous Goods Act Regulations and the CTC Red Book require that in the event of an accident a member of the train crew or the yardmaster make suitable documentation (e.g. consist, emergency response form) available to the relevant public security official.

- Stored Material. This refers to data on DCs stored in the vicinity of railway lines (outside of railway right-of-way). This topic presents certain problems as a result of both a variety of sources and lack of data access in some cases. No legal authority exists to ensure that DC storage be reported to local authorities (e.g. Fire Department, MTEPAC).

  RTC has data on commodities transshipped and stored along the railway rights-of-way. The Provincial Ministry of Consumer and Commercial Relations, Fuel Safety Branch, has responsibility for storage of various types of flammable liquids and gases. No single source of data exists on DCs stored within an urban area, with the result that an incident can occur in the proximity of stored materials, the nature of which may not be known to the emergency forces involved. This is a serious omission and requires prompt rectification by means of revised information legislation and regulation to enable continuous recording of such substances. Bill 101, An Act to Amend the Occupational Health and Safety Act, which has passed the first reading in the Ontario Legislature, in Section 1, paragraph 22, requires that an industry file with the Fire Department and the Medical Officer of Health information on stored DCs.*

Planning/Policy Review Data. The current strategic overview is an example of this form of data use. The main data sources in this study have been the RTC, the CN and the CP. We are very appreciative of the cooperation and assistance provided by these organizations, who have expended considerable effort in responding to study requests. Nevertheless a serious handicap in this assessment has been both the delay incurred and the non-availability of specific key items of information. The RTC deals primarily with rail accident statistics and reports. To obtain rail traffic data and operating information, the analyst is directed to the railways as sole source.

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* A recommendation tabled at the University of Waterloo Workshop on Dangerous Goods, April 28-30, 1986, read as follows: "Current information regarding the storage of dangerous goods within a municipality must be made available to emergency services."

As mentioned, the railways have responded well to what must be an inconvenience and expense. For a number of reasons, this is not a satisfactory situation for reviews of this nature.

- The railway regional offices are operating centers and likely not equipped to deal with intensive data requests - in some cases data was available but only at considerable cost of tabulation,.

- Whatever the circumstances, the situation where an investigating body is dependent for operating data upon the very agencies being studied is not satisfactory for obvious reasons.

The following Table 3.1 taken from a recent US report[1] lists at least eight data sources, most of which are federal agencies. These sources are based on a number of specific, annual surveys or compilations of rail operating and performance records. In our opinion, there should be an agency source for Canadian data of this nature based in the federal government. Their data should be based on an annual record of basic rail operating and performance statistics, most of which would be routinely compiled by computer by each carrier. Without such routine and up-to-date records, it is difficult to expect planning or research studies to be carried out effectively.

TABLE 3.1

USES OF US DATA SOURCES

1. Determining 'Exposure' by Track Class:
   - FRA/Network
   - Princeton
   - State Rail Plans
2. Modeling Train Accidents
   - FRA/RAIRS
3. Modeling HAZMAT Train Accidents
   - FRA/RAIRS
   - MTS
   - NTSB
   - AAR/RPI
4. Modeling Impacts
   - MTB
   - Prior Investigations

Note: FRA - Federal Railroad Administration.
RAIRS - FRA Railroad Accident Incident Report System.
MTB - Materials Transportation Bureau.
NTSB - National Transportation Safety Board.
AAR - Association of American Railroads.
RPI - Railway Progress Institute.

Research Studies. It would be expected that the above-mentioned planning/policy reviews could be based on the macro-type sources referred to above. The additional intensive research required in this field (e.g. risk analysis, performance research, etc) will likely call for, in addition to the above data, more specific and detailed information than could be provided on a routine basis. For example, intensive research on the correlation between accidents and operating or mechanical parameters would undoubtedly call for detailed and accurate records. Acquisition of specific data from private sources (including railways) should be accounted for in study funding.

Conclusions

The above subjects undoubtedly include those measures receiving the greatest attention in recent years, and in the case of retrofit, represents the greatest levels of actual investment and safety improvement. While recognizing that much can still be done in some of the above areas, it should be noted that, as a result of the major efforts made, in many of these categories we may be approaching conditions of diminishing returns. That is, for an increasing level of investment required, we are likely receiving a decreasing level of safety--that is, less-and-less bang for the buck.

3.2 - MINIMIZE THE PUBLIC IMPACT OF EXISTING OPERATIONS

3.2.1 - In the short term

(a) - Times of DC Trains

Considering the changing lineside population during the 24 hours, certain times of the day would have fewest people of vulnerable ages and situations who might have to be protected or evacuated in the event of a mishap. More detailed study and discussion with City agencies would be needed to isolate these 'easiest handled' times.

CP Rail's Train 918, the designated train for dangerous commodities from Chatham, traverses the City of Toronto in the late evening. In general, rush-hour periods are to be avoided. In a residential community a daytime period would be less than at night. Desirably, rail and municipal officials could confer to attempt to establish mutually beneficial time slots.

(b) - Concentrate DC Loads

On page 2-14, the daily use of at least three designated DC trains by CP is described. (that is, concentrating DC loads on specific trains.) The advantages for the carrier being:

- the opportunity to concentrate the strictest safety measures on all dangerous shipments,
- to minimize train speed restrictions in turn maintaining line capacity.

If this measure remains in force it would be desirable to schedule such traffic at the 'safest' hour. The optimal time being not totally clear since population levels are lowest during the day in residential areas but not so in industrial zones. Motor traffic is also highest during daylight hours.

The evidence is not clear as to the safest practice--concentrated by train or distributed between trains, that is:

- in spite of optimum safety measures, even railway officials admit that accidents do happen even on the best maintained lines,
- the combined impact of an accident involving a train carrying several carloads of SDC could be compounded over an incident involving a single carload. This could have a devastating effect on a route with narrow rights-of-way and vertical dimensional variations.

Accordingly, it is important to have an impartial look at the options in this case, including dispersing SDC loads, and focusing on public safety. We recommend that the RTC examine this matter carefully to determine the best policy to be followed in rail operations on high density corridors.

(c) - Confine Derailed Cars

In the event of wheels becoming derailed--and initially there is usually only one wheelset that is the problem--it is important to confine it to as narrow a path as possible, particularly over bridges where a fall to a roadway or ravine could damage a tank and cause a spill, even if the preceding track speed was low.

Jordan Guard rails between the running rails should be extended in length to amply cover the bridge approaches. This is a measure that can be used to protect adjacent neighborhoods in areas of special hazard. We recommend that the RTC examine this subject carefully as a means of enhancing safety along high-hazard sections in built-up areas.

(d) - Confine Spillage

If cars following derailment are damaged and leak, it is important to confine or safely direct any spillage. This might require earthworks, berms and shaped channels in particular, and egress control of liquids and heavier-than-air gases. Where the line is on a narrow and exposed embankment, little remedial improvements are possible. Fire Department personnel have expressed concern that such berms or walls would accumulate and channel gases in an undesirable manner.

The Ministry of Housing has advisory standards for municipalities to apply to new residential development, including sight barriers along railway frontages. These standards should provide a starting point for additional safety standards. It would appear that a more concerted and open process of developing such ideas can be carried out by provincial authorities.

(e) - Emergency Procedures

Hazardous goods emergencies in relation to rail services in urban areas occur in several contexts:

- track incidents (moving accidents associated with derailments, collisions and releases due to other causes),
- yard incidents,
- interaction between traffic on rail and on adjacent or intersecting roads,
- interaction between rail traffic and occurrences (e.g. fires, explosions, etc) on adjacent property.

This subject area has a well integrated emergency measures administration focused on the Metropolitan Toronto Emergency Planning Advisory Committee (MTEPAC). This is made up of the following representatives.

Chairman, Metropolitan Toronto Council
Chief, Metropolitan Toronto Police
Coordinator, Metro Police
Controller, Metro Council
Commissioner, Ambulance Services Department
Commissioner, Metro Works Department
Commissioner, Metro Roads and Traffic Department
Commissioner, Metro Community Services Department
Commissioner, City of Toronto Purchasing and Supply Dept.
Chief, Toronto Fire Department
Medical Officer of Health, City of Toronto

Metro Legal Department
Metropolitan Toronto and Region Conservation Authority
Toronto Transit Commission
Medical representative
Toronto Hydro
Consumers' Gas
Bell Canada
Insurance Bureau of Canada
St. John Ambulance
Metropolitan Toronto School Board
Metropolitan Separate School Board
University of Toronto/York University/Ryerson Polytech

The By-law provides that the Chairman of Metropolitan Toronto Council is chief operational officer who may delegate that authority to the Chief of Metropolitan Toronto Police. The coordinator for emergency planning is a member of Metro Police, holding the rank of inspector.

Yard Accidents. It should be noted that 84% of rail collisions and derailments (1984) occurred in railway yards. This represents 31% of all rail accidents. Yard accidents have been increasing while through train accidents are decreasing (i.e. 1983 to 1984 through train accidents down 67%, yard accidents up 39%).[4] Yard accidents are usually much smaller and less serious than many through train accidents. Yard accidents often involve the release of a DC, which could, in certain circumstances, expand into a larger, more serious event. Rail officials, however, stress that the statistics are misleading since many documented yard accidents are made up of reported events which on examination represent no real hazard. As well, the statistical definition of yard accidents changed in 1980 and 1984, which tended to include a wider range of accidents in the totals.

In the event of response by an emergency organization, yard accidents represent special problems:

- they are not always reported to public agencies, especially municipal authorities,
- they can present special difficulties in obtaining access to the accident site,
- they can have potential for expansion as a result of the variety of DCs that may be located in nearby standing freight cars.

In a recent US report on railway yard safety, accidents in railway yards were cited as first or second in an urban community survey ranking DC-oriented hazards.*

The following rail yards are located within Toronto (Figure 1.1).

CN West Toronto Yard
CP West Toronto Yard
CP Parkdale Yard
CN Don Yard
CN Danforth Yard

(Note: Existing yards in the Union Station area will be eliminated according to the Railway Lands Development Plan. Other yards existing just beyond City boundaries include: CP Lampton Yard and CP Leaside Yard.)

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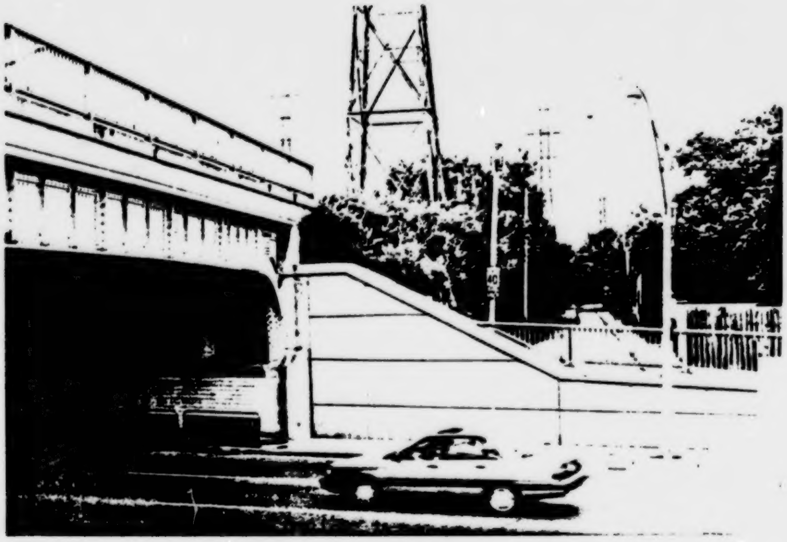
* Special Investigation Report, Railroad Yard Safety - Hazardous Materials and Emergency Preparedness, NTSB, Washington, D.C., 20594, April 30, 1985.



Facing east along Marlborough Avenue across Avenue Road. Housing built on south slope of North Toronto subdivision. Transmission line on railway right-of-way. Illustrates elevated track section.

Looking south from elevated embankment of North Toronto subdivision into catch basin down Avenue Road.

Factors for consideration in the event olf rail yard emergencies include:

Notification. In order to deal effectively with an incident emergency affecting the adjacent community, it is important that municipal forces (i.e. fire department, emergency measures, police) be notified as early as possible. Regulations affecting notification include:

- The Railway Act requires CTC notification by the railway of an incident involving a fatality, over $750 property damage, or dangerous commodities.

- The Ontario Spills Bill (Part IX of the Environmental Protection Act) requires that industry inform the Ministry of the Environment of the spill of a dangerous commodity plus contact with a suitable municipal representative.

Cooperation. There must be a specified party with responsibility for direction and coordination of emergency operation. Preferably this should be a municipal official. In the case of Metropolitan Toronto, this is the Metro Toronto Council Chairman (the Chief Operational Officer of MTEPAC) or his delegate, the Chief of Police.

Security. Access to or egress from accident site or area should be strictly controlled. All important railway or industry personnel must be accessible and in the vicinity (e.g. conductor or important railway executives.) Within Metro Toronto, security is the responsibility of Metro Police, except for railway rights-of-way where railway police have jurisdiction. In the case of serious accidents, the area around right-of-way is in the charge of Metro Toronto forces.

Two other matters are significant.

Emergency Planning. A railway network increasingly is similar to a chemical industrial facility with high interaction between the components.* It is essential that an emergency plan be developed for the railway lines within Metropolitan Toronto, reflecting the various related elements, i.e. tracks, yards, multimodal facilities, intersecting roads, land use, population, industry, institutions in the corridor.

Emergency Evacuation Exercises. A number of emergency evacuation exercises have been carried out in the City of Toronto, MTEPAC and the Toronto Board of Education. Such exercises are beneficial in improving public awareness, and helping emergency forces familiarize themselves with the particular logistical problems associated with different locations and conditions, or with evacuations in general. It is recommended that such evacuation exercises be arranged for locations within Metropolitan Toronto as a whole and be related specifically to rail operations.

(f) - Hazard Penalty Compensation

As shown in Table 2.11, page 105, over 50% of both the residents and the employees in the City of Toronto are located within the range of impact of the City's rail corridors. As designated, there are two levels of impact; a high consequence zone and a medium consequence zone. While a precise measurement of hazard probability for the two zones is likely not practicable, a definite gradation of hazard is recognized. It could be argued that these members of the population are exposed to unique dangers that other members of the public do not experience, and that there is little direct personal or wider municipal benefit associated with transport operations creating these hazards. That is, the special hazard links (i.e. North Toronto, Galt west and Mactier subdivisions) carry high levels of through DC shipments (Table 2.7, page 77) which do not start or finish in the Toronto CMA.

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* The Railway can be described as a chemical conveyor between processing plants, i.e. an integral part of the industrial chain, to be treated with as much caution as the plants themselves, perhaps with more caution due to the energy of transport.

In theory this raises the question of a form of penalty placed upon the occupants of this corridor for which some compensation could be justified. In such a case, a theoretical form of compensation could be considered, such as:

- a tax surcharge applied to the industries shipping or receiving the commodities,
- this surcharge converted into compensation to the corridor occupants.

At first glance this is a radical concept that has not heretofore been recognized by the financial community in the form of adjustments in property values and/or insurance rates in the corridors affected.

Its best relevance is perhaps as an economic mechanism for costing the hazard penalty. This has community precedents again in the areas of flood plains and airport flight paths, where long-term potential hazards are costed in relation to probabilities and estimated damages. Such cost estimates can be used as a measure of benefit when planning possible alleviation or diversion schemes. In this case, the approach could be used by the federal Task Force in its examination and appraisal of rail traffic diversion alternatives, as one measure of possible benefit.

3.2.2 - In the Long-Term

The main category of action associated with long-term relief to proposed impacts of rail DC traffic is the provision of land use controls on the consequence zones--that is, to essentially lower long-term land use and population densities in the corridor.

Land Use Control Measures

The potential for DC accidents to affect large areas of land makes it very difficult to suggest effective mitigation measures involving land use controls. The density and complexity of existing land uses surrounding rail lines in the City serve to further complicate the issue.

Nonetheless, it is clear that, if it is truly convinced that DC movements pose a real hazard, the City must form and implement a planning policy. It is suggested that criteria should be developed to assess development proposals and rezoning applications with a view to preventing the construction near the right-of-way of buildings which are:

- high density residential
- over 2 to 3 stories in height
- institutions for care, such as hospitals, nursing homes, day care and group homes for physically or mentally handicapped persons
- schools
- residential buildings for use by seniors
- jails or detention centers.

Shopping centre at Dupont Street and Dufferin Street in high consequence zone of North Toronto subdivision.

Symington Avenue facing south, south of Dupont Street in junction triangle and high consequence zone of North Toronto subdivision.

Strachan Avenue level crossing. Massey-Ferguson site on left. Main line signals and major redevelopment.

Looking north west. Multiple use development on Galt/Weston corridor at Bloor St. shopping centre, high-rise apartments, offices. High School on south side of Bloor Street.

The major concern with these uses is that they are used by people who are difficult to evacuate in an emergency. Both children and seniors are vulnerable to gases in even low concentrations. High rises are vulnerable to blast and fireball effects. Commercial high rises also tend to have large glass surfaces which can become projectiles in BLEVE or similar concussive event.

While forbidding certain land uses may avoid the exacerbation of an already existing problem, it does not answer the question of what land uses should be encouraged. The City should seek to encourage and approve the location and land uses which would be relatively insensitive to the DC hazard. Residential land use and certain institutional uses are clearly the most sensitive. Office-commercial is sensitive during the working hours, but insensitive during other times. Retail-commercial, provided it does not involve shopping centers and other dense nodes, is relatively insensitive because population concentrations tend to be distributed over the working day, and are nonexistent at night. Industrial land use varies in characteristics from high to low sensitivity. Parks and other open spaces can also be insensitive due to the low numbers of people, generally broadly dispersed, to be found in them at any one time.

The sensitivity of land uses poses severe planning and economic problems. Demand for industrial and park land is not very high in the City. The greatest demand is placed on residential land use, high density in particular, and office-commercial uses. This implies a conflict between what is economically desirable and what is safest in the face of improbable hazard.

Dealing with the existing land use pattern poses some thorny problems as well. To declare all residential and sensitive institutional land use in the HCZ, or a part thereof, to be legal non-conforming would be very controversial. Nonetheless, consideration should be given to regulating new building activity in the most sensitive areas.

Municipal Options

As has been discussed above, high proportions of population, employment and other demographic categories are presently located in the consequence zones of the rail network in the City (see Tables 2.11, page 105). With regard to DC traffic flows, a number of future options present themselves. Basically, this divides into the diversion of through movements (DC and/or non-DC shipments) which have been estimated at about 80% of total corridor flows, and/or the application of risk management measures to the remaining traffic. Nevertheless, any plan for diversion will undoubtedly take many years to implement, thus requiring the City to cope with essentially existing conditions of DC transport.

The City therefore is faced with the passage of dangerous traffic by rail within its boundaries for some time to come. Furthermore, the concept of traffic diversion cannot apply to certain lines within the City where virtually no through traffic exists. Fortunately, there is little DC traffic currently on these lines. Nevertheless there is always the future possibility that DC volumes may increase on these routes. However, the introduction of heavy DC volumes on these lines is unlikely.

Regardless of the outcome of the Federal Task Force's deliberations, some redefinition of zoning practices for these corridors must be investigated. A final agreement on such policies will undoubtedly await the resolution of the long-term rail system plan, currently under consideration by the Federal Task Force.

Another consideration is the expected low rate of growth in these corridors. As a result of which any new zoning controls would have little effect on short-term population levels in these corridors.

There are a number of mechanisms available for regulating new development activity on lands adjacent to railway lines within the City, such as:

- Official Plan policy statements
- Zoning By-law restrictions
- Site Plan Control
- Subdivision Control
- Committee of Adjustment
- Redevelopment areas.

The evision of any or all of the above mechanism to affect development over such a large area as that covered by the consequence zones would represent a major disruption of City policies and may, in the long term, be rendered unnecessary by the outcome of the Federal Task Force's studies.

Accordingly, it is suggested that rather than immediately recommend specific zoning restrictions for these areas, a careful examination be carried out of various control mechanisms under different risk management scenarios possible on the rail lines in this region.

It is therefore recommended that the City Commissioner of Planning and Development be requested to proceed with the development of an appropriate interim or short term land use policy for regulating new development adjacent to railway corridors. The definition of a suitable long-term land use policy should await the final outcome of the Federal Task Force's studies.

Development Constraints

It is apparent that development and growth along the City's rail corridors is not totally dormant. A field trip along the Galt/Weston and North Toronto corridors provides several examples of recent high density development directly abutting the rail right-of-way--for example, the Bloor/Dundas shopping center and Lambert Lodge. This raises an important question--how many similar developments have been approved but not built?

This review of hazardous rail traffic raises key questions for the City:

- If the DC traffic is not diverted how much high-density development will be prohibited as a result of revised zoning controls?

  In this event what happens to the existing high-density development? That is, by recognizing a hazard along these routes, is the City obliged to provide special protective features for these properties?

  These considerations indicate an implicit economic penalty incurred on the City by the existence of heavy rail DC volumes. This, in turn, can be converted into a possible benefit to the City in the event of traffic diversion.

  Again, we can recommend that the federal Task Force in its evaluation of bypass routes consider the question of potential land use development opportunities to the municipality.

* * * * * *

Conclusions

The above measures, designed to mitigate the impact of rail accidents are, in some cases, unconventional and have not received the attention applied to rail operations and equipment.

Since the existing rail operations on the City network are likely to continue for several years, regardless of the outcome of current researches, it is essential that the above measures receive careful attention for possible application. These matters in some cases will be covered in later recommendations.

3.3 - TO REDUCE THE AMOUNT OF DANGEROUS GOODS TRAFFIC THROUGH TORONTO

3.3.1 - Ban on Movement Through the City for All or Selected Dangerous Commodities

An extreme position that could be adopted by the federal authorities is a ban on DC and/or SDC rail traffic within the City of Toronto. There is no exact precedent for such a move across Canada, although the removal of DC traffic from a CP Rail line serving the Vancouver waterfront is the closest analogy. That example is possibly more akin to a possible ban on LPG and toxic gas shipments through downtown Toronto.

This possible directive is briefly examined below in terms of form of the objectives beginning of this chapter.

- to optimize public safety,
- to minimize public exposure,
- to enhance local industry,
- to enhance railway operations.

Public Safety and Exposure. These two goals can be reviewed simultaneously. Certain areas of the City can be considered particularly susceptible to SDC hazard. For instance:

- Prohibiting the transport of LPGs or toxic gases through the Union Station area should be considered because of the extreme hazard posed by gas releases or LPG incidents in this area (see Section 2.6.2 above).

- The North Toronto Sub with its narrow rights-of-way, bridges and the proximity of catchment basins, plus the approximately 4000 carloads of SDCs carried annually (1950). (See Table 2.2)

- The Galt west and Mactier subdivisions with dense population concentrations, and approximately 6000 and 12 000 SDC carloads respectively (1985). (See Table 2.2)

According to the hazard profile assessment (see Section 2.7) the above represent the special hazard sections in Toronto (with the exception of the TTR section which is a special case). Banning DC or SDC through shipments on these sections would represent a high level of priorizing risk-management measures in Toronto. As well, removal of SDCs and/or DCs over the above subdivisions would essentially remove the main rail hazard from the City and would, to a large degree, eliminate public exposure to rail transported dangerous chemicals.

DCs versus SDCs. Table 3.2 below indicates the respective proportions of DC, SDC and total traffic.

TABLE 3.2
PROPORTION OF DC TRAFFIC, CITY OF TORONTO
(Subdivision Traffic, Six Months, 1985)

	Total Subdivision Carload Volumes Percent
Special Dangerous Commodities	0.7
Dangerous Commodities	3.6
Non-Dangerous Commodities	95.7
Total	100.0

Source: CP Rail.

The above indicates that for the removal of a very small proportion of rail freight traffic (0.7%), a large part of the rail hazard could be excluded (i.e. Special Dangerous Commodities).

It should be noted that the SDC/DC distinction is somewhat arbitrary, and there are a large number of dangerous substances in the DC category, i.e. most of the flammable liquids and corrosives, and so on. Although much of the more spectacular substances would be removed with an SDC ban, the hazard to the public would certainly not be completely eliminated. However, directing all DC shipments would remove only 4% of the rail shipments through Toronto.

Effect on Industry. CP Rail records 66 SDC shipments at the West Toronto Yard in 1985. Other than that, there appear to be no other SDC deliveries within the City of Toronto, and that SDC traffic represents principally through movements (in terms of the City only). Supposedly, then banning SDCs from Toronto could be done without directly affecting City industries.

This cannot be said without considering the likely effect on the other cities and boroughs in Metropolitan Toronto. If we consider three categories of freight shipment disposition, i.e.,

(i) origin or destination within City of Toronto
(ii) origin or destination in other parts of Metropolitan Toronto
(iii) origin and destination outside of Metropolitan Toronto or environs.

Item (i) can be considered totally local traffic, item (iii) can be considered totally through traffic, and item (ii) is likely to be included among SDC or DC traffic passing through the City of Toronto. Accordingly, by banning item (ii) category trips you may not inconvenience Toronto (City) industry but will definitely inconvenience traffic in other boroughs (i.e. East York, Scarborough, Etobicoke, etc).

Effect on Railways. The ban would likely include only trips totally bypassing the Metropolitan Toronto area. There would undoubtedly be a community disadvantage in driving away rail service from the City industries. Not only might this create financial problems for both industry and railways, it could drive the freight traffic to the less-desirable automotive trucking mode, or worse still, cause industrial relocation.

A critical issue would be the rerouting of the displaced traffic. This would likely be a direct concern for the CP only since much of CN shipments have already been diverted to the York Sub in Markham/ aughan Townships. Nevertheless, CN expresses concern about possible diversion to heavily traveled CN routes. Section 3.3.3 below deals with the subject of rerouting or relocating facilities for serving bypassed traffic, and the advantages and disadvantages of the specific options.

The possibility of a ban on DC or SDC shipments by rail within Toronto has some advantages. Such a ban should only include trips 'through' the Toronto CMA. We recommend that the Federal Task Force carefully assess this option.

3.3.2 - Minimize Excess Movement

(a) - Backhauling

Major railways in North America were ahead of deregulated airlines in developing lean networks on the 'hub and spoke' principle. By consolidating traffic on certain high-volume corridors, the railways achieved economies of scale in line-haul operations. By focusing movement on relatively few well-equipped yards (normally only one in each metropolitan area), they were able to minimize terminal costs. Any consequent out-of-the-way movement of individual cars and loads was more than offset by economies of scale on the favored routes.*

Applied to the Toronto region, these principles mean that locomotives and vans for long-distance CP trains are serviced, manned and dispatched exclusively from the Toronto Yard at Agincourt, and nearly all numbered trains originate or terminate there.

Loads from SW Ontario to western Canada or northern Ontario have had to traverse the North Toronto Subdivision twice--once easterly to the Yard at Agincourt in an incoming train, and once in reverse in an outgoing train to the north.

In practice, blocks of some through loads have been set out at Lambton Yard in the west and, relayed by a local movement to the Ray Avenue Yard on the Mactier Subdivision at Mount Dennis, whence they are picked up by a train for western Canada originatting in Toronto Yard at Agincourt. A saving in ton-miles is effected, but at the cost and complication of stopping a mainline train at Lambton and another at Ray Avenue, and of an inconvenient reversal during the movement between these two yards.

Using a west-end yard to assemble through loads for trains heading north is to be commended, and should be facilitated and extended as soon as possible.** Incoming trains from the north similarly should have blocks of cars for setting out at Ray Avenue, if this is not already done. The operation of the proposed Vaughan intermodal terminal (near Kleinberg) will remove several trains from western Canada currently traveling through Toronto en route to the Obico terminal in Etobicoke.

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* For example, Conrail effectively abandoned uses of the shorter Canada southern route across southern Ontario between Detroit/ Windsor and Niagara Falls in favor of adding the traffic to its line south of Lake Erie, via Toledo.

** Both railways adopted the principle of a west-end yard when they built intermodal terminals at Obico (CP) and Brampton (CN). Trains of containers and highway trailers originate and terminate there, sparing the North Toronto Subdivision and its counterpart, the

(b) - Stopping, Starting and Reversing

The safest rail movement from A to B would be at a uniform moderate speed. Stopping and restarting involves dynamic forces which could fracture any weakened components. Stops en route by trains carrying DCs through urban areas should be avoided except where necessary for serving customers where justified for net gains in safety, as in the case of the stop at Lambton Yard discussed above. Dispatchers should arrange paths for DC trains that avoid the need for stopping, slowing or crossover movements.

In place of reversals on the North Toronto Subdivision which presently are necessary during moves from Lambton to Ray Avenue (see 3.3.2 (a)),a new link should be investigated between the Galt and Mactier subdivisions, in the NW quadrant of the west Toronto rail intersection. Such a link would entail considerable property acquisition, but the likely operating safety and efficiencies may justify the expense.

3.3.3 - Alternative Routes for Dangerous Commodities

Sections 3.1 and 3.2 focus on measures to optimize conditions of the existing operations along the present-day network within Toronto. Although a wide range of measures is considered, it must be recognized that as further attempts are made to achieve greater safety on existing

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Halton Subdivision, of double movement by loads in transit.

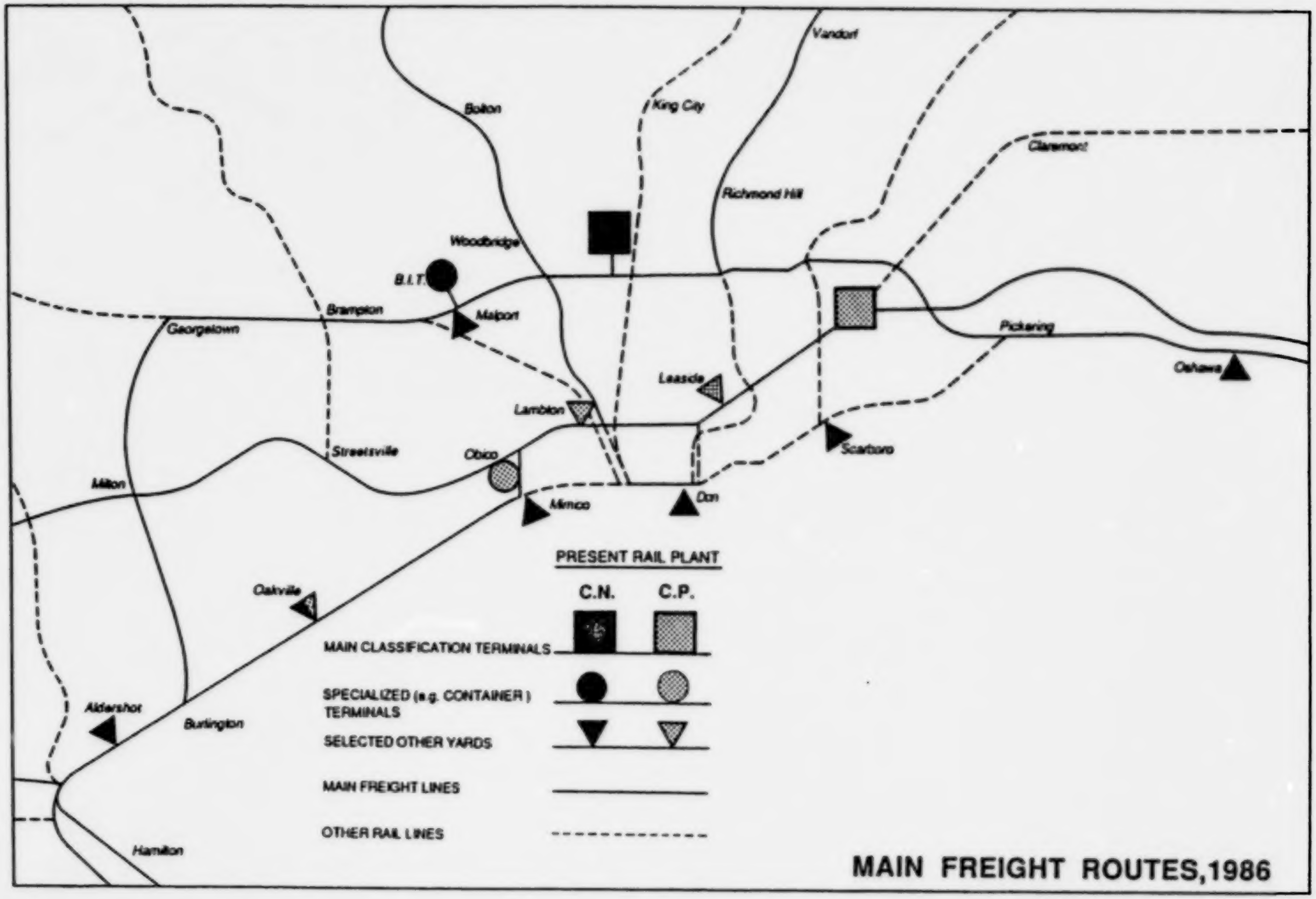
facilities, there is the increasing likelihood of lower increments of safe operation resulting from greater increments of investment. Nevertheless, in spite of all such improvements, as a result of unpredictable and uncontrollable factors (i.e. human error, mechanical failure, climate conditions, etc), a large proportion of the population of the City of Toronto remains exposed to rail incidents. Since the displacement of population is not feasible, the diminishing of population exposure by means of the diversion of volumes of through DC shipments from City routes should be investigated.

The following discussion deals with a number of possible options for DC traffic diversion. A goal of such measures is to ensure that any diversion should not represent the transfer of a threat from this community to another. The objective must be to develop rail corridors that are protected from land use and population incursions that would recreate the original conditions of public hazard. In their original commentary on the Burton-Post Report (1983) the CN stated:

> "Legislation should be introduced to ensure property adjacent to the railroad right-of-way is protected from urban development. Lack of such legislation could result in a public outcry to have the rail lines relocated every 25 years or so."

On page 75 above in Chapter 2, the question of through or divertible traffic is considered and the table on page 77 indicates that approximately 75% of DC and SDC traffic is considered through traffic (i.e. passing through Toronto CMA) along the CP North Toronto subdivision. In the following discussion four alternative routes are considered in a preliminary way as possible corridors. These are shown on Figures 3.2 to 3.5 preceded by Figure 3.1, a sketch map of current main freight routes in the Toronto area. The alternatives are discussed as follows.

Figure 3.1



MAIN FREIGHT ROUTES,1986

Vandorf
Bolton
King City
Claremont
Richmond Hill
Woodbridge
B.I.T.
Brampton
Malport
Georgetown
Pickering
Oshawa
Leaside
Lambton
Streetsville
Obico
Scarboro
Milton
Mimico
Don
Oakville
Aldershot
Burlington
Hamilton
PRESENT RAIL PLANT
C.N.
C.P.
MAIN CLASSIFICATION TERMINALS
SPECIALIZED (e.g. CONTAINER) TERMINALS
SELECTED OTHER YARDS
MAIN FREIGHT LINES
OTHER RAIL LINES

(a) - Finch Hydro Corridor (Figure 3.2)

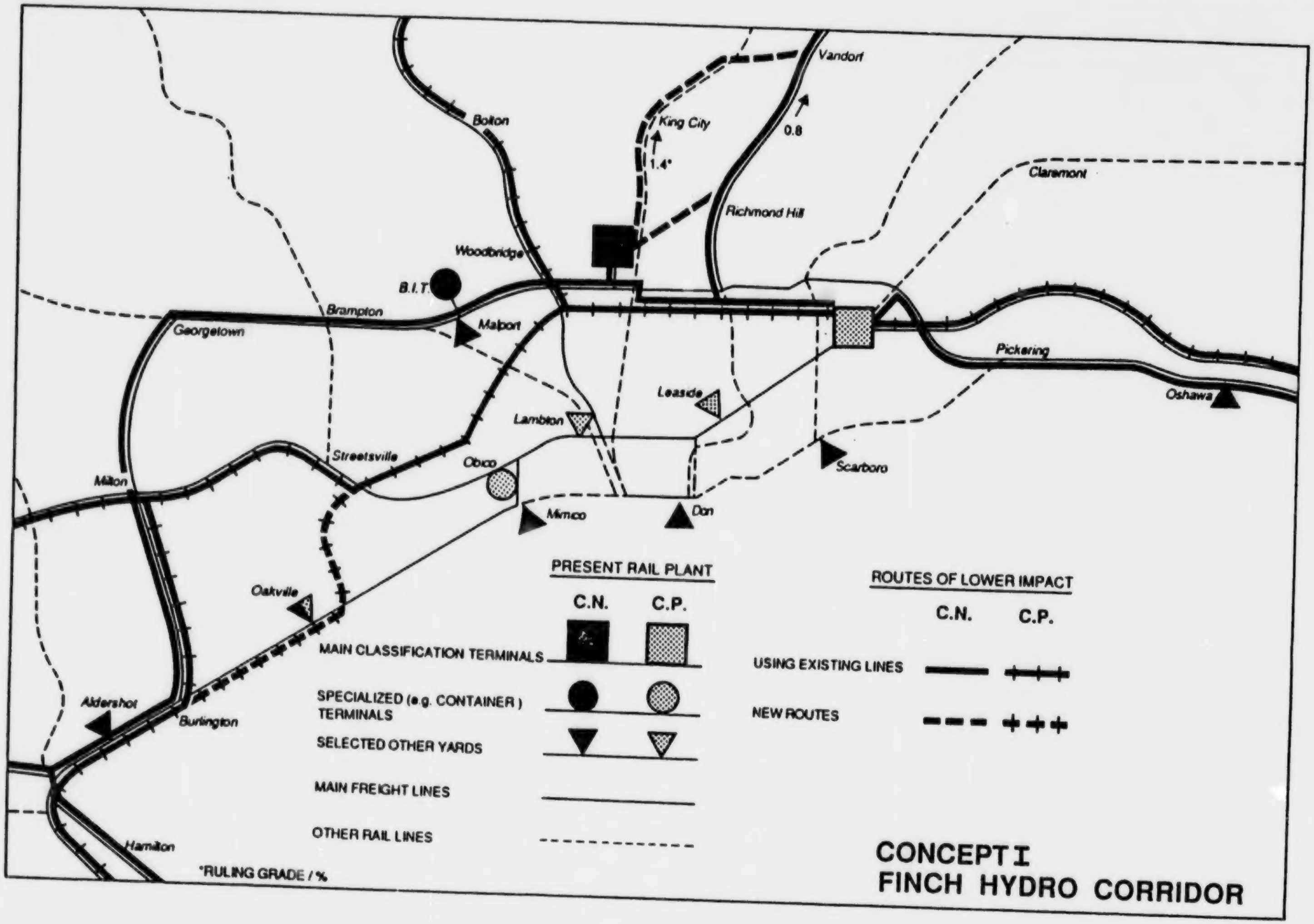
Main Features

- Following an existing hydro transmission line corridor between near Streetsville and Toronto Yard at Agincourt, a distance of 30 miles, this deviation caters to some or all of CP's traffic from southwestern (Galt S/D) and southern (TH&B) gateways, and to CN's eastern traffic between CN's Newmarket and York S/D's (15 miles).
- The corridor closely parallels Highway 403 in Mississauga and Finch Avenue in Metropolitan Toronto.
- A gas pipeline is located throughout much of the length of this corridor.

Assessment

- The alignment is generally favorable in network terms, passing within a mile or so of both main yards. Accordingly, lateral access lines to yards are held to a minimum.
- Unfortunately, the existing right-of-way, tightly bounded by urban uses for almost its entire length, is too narrow to meet preferred standards for the separation of DC rail traffic from residential properties. The half width is only 170 ft in places, whereas at least 500 ft is desirable on level open ground.
- There are several jogs in the right-of-way, complicating the alignment for railway purposes unless land were taken to extend clearances.

Figure 3.2


Vandorf
King City
1.4*
0.8
Bolton
Claremont
Richmond Hill
Woodbridge
B.I.T.
Brampton
Malport
Georgetown
Pickering
Oshawa
Leaside
Lambton
Streetsville
Obico
Scarboro
Milton
Mimico
Don
Oakville
Aldershot
Burlington
Hamilton
PRESENT RAIL PLANT
C.N.
C.P.
MAIN CLASSIFICATION TERMINALS
SPECIALIZED (e.g. CONTAINER) TERMINALS
SELECTED OTHER YARDS
MAIN FREIGHT LINES
OTHER RAIL LINES
ROUTES OF LOWER IMPACT
C.N.
C.P.
USING EXISTING LINES
NEW ROUTES
*RULING GRADE / %

CONCEPT I
FINCH HYDRO CORRIDOR

- The longitudinal profile is difficult, given the impossibility of deviating the alignments to ease gradients in and out of river valleys like the Don west of Leslie Street. Heavy cuttings and/or viaducts might be required.

- The right-of-way is presently occupied by three lines of transmission towers. While these might be relocated in whole or in part, major switching stations would be a major impediment.

- Electrical transmission lines interfere with train radio communication.

(b) - Augmented CN Bypass (Figure 3.3)

Main Features

- This concept makes use of existing facilities, expanded in capacity where necessary, to accommodate certain CP trains.

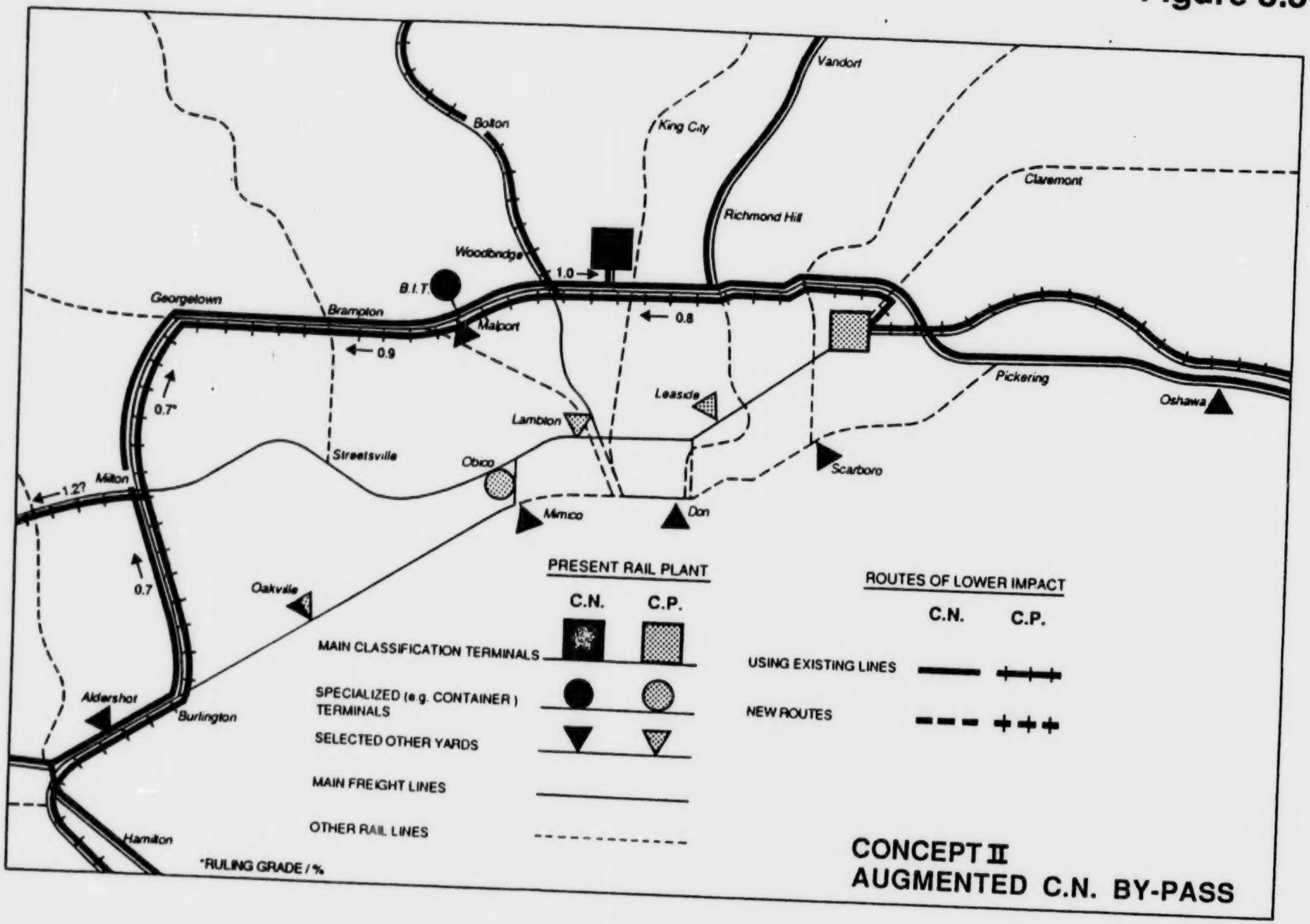
- Preliminary cost estimates of the modifications were made by CN in 1983 at $138 Million.

Assessment

- The alignment comes reasonably close to both main yards, the capital cost is relatively moderate, but CP would incur extra haul distance, especially to/from the southwest and the south.

- Encroachment by urban development in recent years has created vulnerable frontages along the line totaling many miles. This limits its effectiveness as a safety bypass for CP traffic, even for interim purposes. It would represent poor value for the money spent in modifying it for CP use. The RTC

Figure 3.3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Oshawa
Leaside
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Lambton
Streetsville
Obico
Scarboro
Milton
1.2?
Mimico
Don
0.7
Oakville
Aldershot
Burlington
Hamilton
PRESENT RAIL PLANT
C.N.
C.P.
MAIN CLASSIFICATION TERMINALS
SPECIALIZED (e.g. CONTAINER) TERMINALS
SELECTED OTHER YARDS
MAIN FREIGHT LINES
OTHER RAIL LINES
ROUTES OF LOWER IMPACT
C.N.
C.P.
USING EXISTING LINES
NEW ROUTES
*RULING GRADE / %

CONCEPT II
AUGMENTED C.N. BY-PASS

accordingly dismissed this concept as an interim measure (which had been recommended by the Barton-Post report).

(c) - Modified Parkway Belt (Figure 3.4)

Main Features

- This concept addresses weaknesses in the CN bypass as a safety route, particularly its circuitry, vulnerable urban frontages and lack of future protection.

- The Province's designated Parkway Belt West is used for 45 miles as a host corridor affording this needed protection.- Urban areas at Georgetown and Brampton are bypassed by a more direct route for CN traffic, (A), (D) (see figure for key letters).

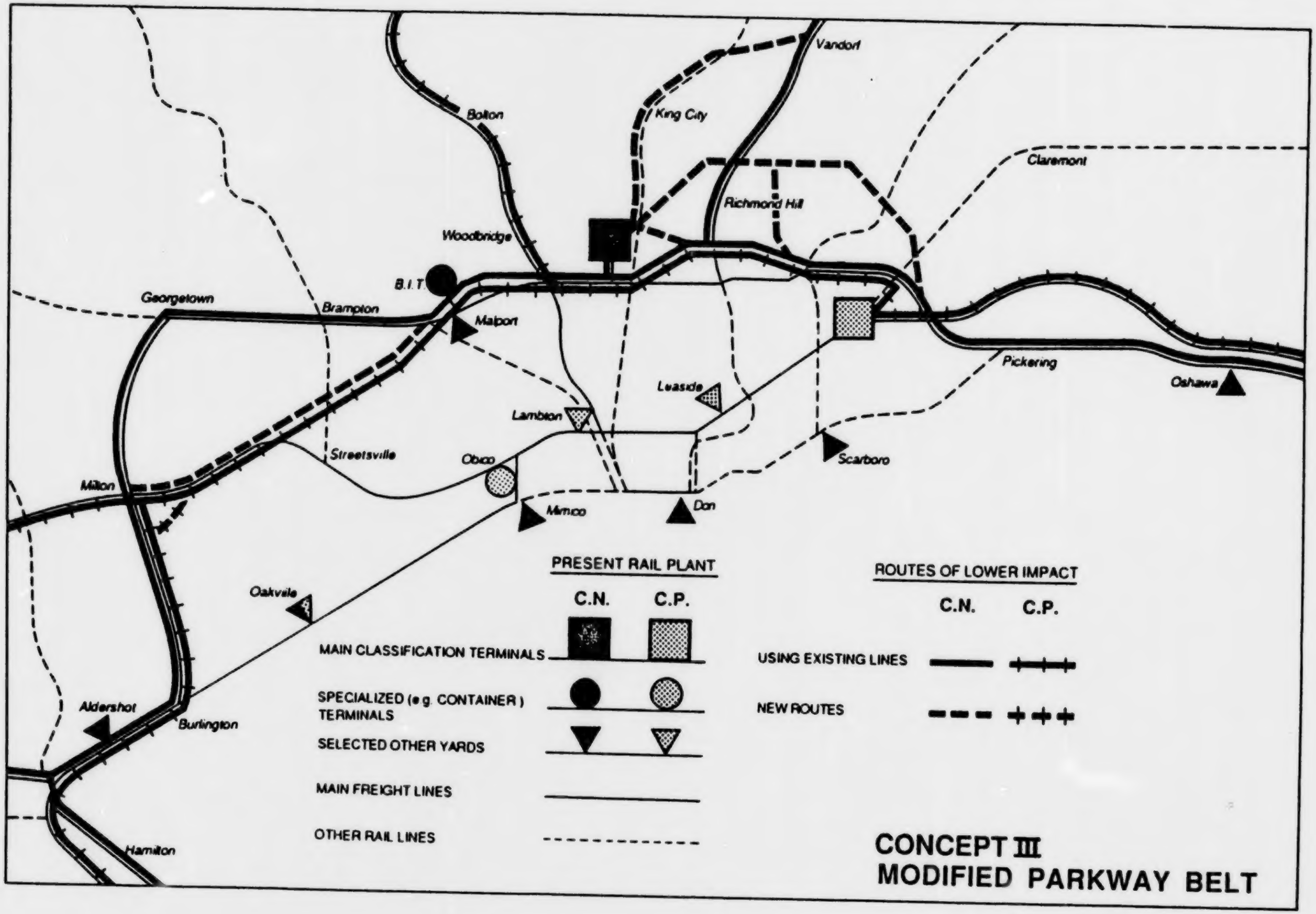
- Between Halwest and Humber the rail alignment is set back deeper into the Belt to relieve present impacts, (B).

- Between Keele Street and Hagerman Junction, the line deviates northward to avoid Thornhill impacts and pass through the Langstaff gap beside future Highway 407, (C).

Assessment

- The Parkway Belt allocates space for two high-voltage electrical transmission lines, one of which has been built. This is expected to interfere with train radio communications. Limited-access Highway 407 will occupy part of the remainder. The extent of certain interchanges leaves little room for another facility at ground level. A commitment to redesign Highway 407, to adjust parts of the transmission line, and to acquire additional land where necessary to widen the Belt,

Figure 3.4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Pickering
Oshawa
Leaside
Lambton
Streetsville
Obico
Scarboro
Milton
Mimico
Don
Oakville
Aldershot
Burlington
Hamilton
PRESENT RAIL PLANT
C.N.
C.P.
MAIN CLASSIFICATION TERMINALS
SPECIALIZED (e.g. CONTAINER) TERMINALS
SELECTED OTHER YARDS
MAIN FREIGHT LINES
OTHER RAIL LINES
ROUTES OF LOWER IMPACT
C.N.
C.P.
USING EXISTING LINES
NEW ROUTES

CONCEPT III
MODIFIED PARKWAY BELT

would be necessary to meet railway objectives and design standards, particularly in the Langstaff area.

- If this commitment cannot be secured, it may be necessary to lengthen the railway to pass north of Richmond Hill (Figures G and H).

(e) - Oak Ridges Belt Line (Figure 3.5)

Main Features

- A joint-use deviation is formed of existing lines, an abandoned line, a new route easterly to Vandorf along the Simcoe-Ontario watershed and a new link from Vandorf down the ridge between the two branches of the Rouge River to Mile 8 approximately, near Beare, on CN's York S/D, with a connection to the CP Havelock S/D for access to Toronto Yard.

- Connections are necessary from the CP Galt S/D at Milton and from the CP Mactier S/D at Humber north of Bolton.

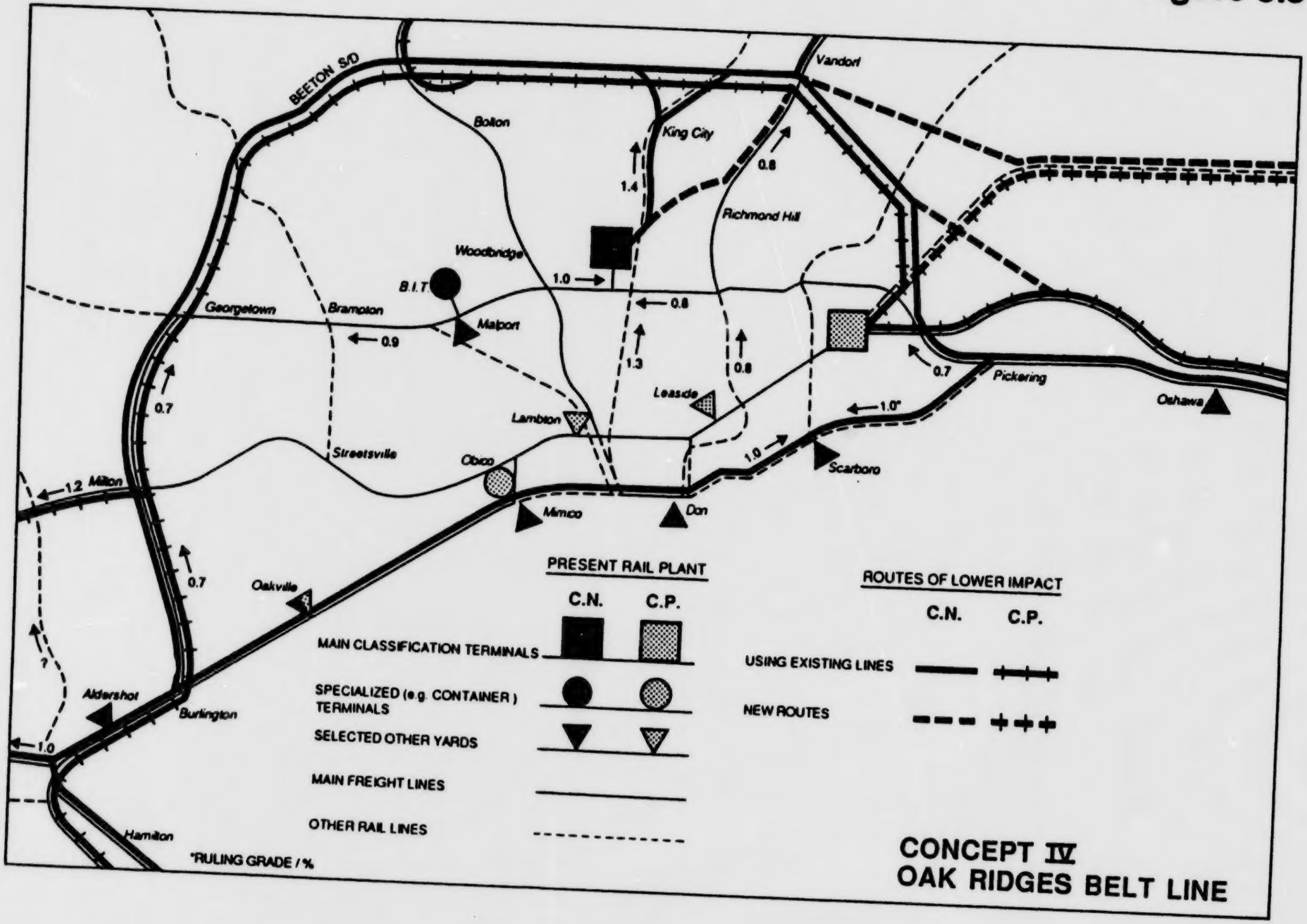
- The northern approach to MacMillan Yard is rationalized to relieve Richmond Hill, and the York S/D, and to shorten haul distance.

Assessment

- Although this is the longest scheme of the five, once clear of the foot of the Escarpment it is economical in bridge requirements and it stays clear of valuable farmland for much of the way.

- CN incurs 20 miles extra haul to the MacMillan Yard from all directions except north. CP incurs even greater operating

Figure 3.5


BEETON S/D
Vandorf
Bolton
King City
1.4
0.8
Richmond Hill
Woodbridge
B.I.T.
1.0
0.8
Georgetown
Brampton
Malport
0.9
1.3
0.8
0.7
Pickering
Oshawa
Leaside
Lambton
Streetsville
Obico
1.0"
1.0
Scarboro
1.2 Milton
Mimico
Don
0.7
Oakville
?
Aldershot
Burlington
1.0
Hamilton
*RULING GRADE / %
PRESENT RAIL PLANT
C.N.
C.P.
MAIN CLASSIFICATION TERMINALS
SPECIALIZED (e.g. CONTAINER) TERMINALS
SELECTED OTHER YARDS
MAIN FREIGHT LINES
OTHER RAIL LINES
ROUTES OF LOWER IMPACT
C.N.
C.P.
USING EXISTING LINES
NEW ROUTES

CONCEPT IV
OAK RIDGES BELT LINE

penalties except again from the north. Through traffic from north to west on CP could save 25 miles if Toronto Yard were not a port of call. Any additional operating cost could nullify distance savings.

- DC-carrying freight trains are removed from all urban corridors in the Toronto area except those in the Region of Durham, but the deviation is well positioned to allow for an extension around the urban areas of Durham should that become necessary. Pressure of urban encroachment would then be limited to Milton, Georgetown and North Burlington.

- This scheme could remove heavy freight trains from the paths of almost all GO trains, facilitating expansion of GO service.

3.4 - EVALUATING THE OPTIONS

In the foregoing some 32 topics have been discussed, each representing a specific means of enhancing rail safety in Toronto. They cover a wide range of possible action including the possible use of hazard insurance on the one hand, and the construction of a major bypass facility on the other.

In order to provide an overview of these diverse prospects, an evaluation of these alleviation measures, according to common criteria, has been carried out, the results of which are displayed on Figure 3.6. In this chart the 32 alleviation measures are listed.

In the left column, a listing of overall objectives, which are divided into two essential safety objectives--public safety improvement and the limiting of public exposure; and six desirable objectives which are important goals, but not as critical as the essential objectives.

In relation to the objectives each measure has been assessed according to its effectiveness in enhancing rail safety conditions. Three comparative criteria are used:

- A medium or neutral category representing a condition either of little effective change in terms of the specific objective, or the case where the measure has little apparent influence upon conditions associated with the objective in question.

- Either a low or a high category, each representing a significant difference in the conditions associated with the specific objective, that is, a lower or higher degree of effectiveness.

Figure 3.6 can be used as a basis for a rough comparison of measures.

The results should be used with some caution. A best overall measure should not be sought. First, the individual assessments are based on judgments. Second, the respective objectives may vary in importance in a relative sense. Further, these results are generalized and should not be the basis of any decisions at this stage.

There is likely to be no one specific solution to the overall problem of rail safety. The goal should be to search for the best overall combination of key safety measures which in combination can meet agreed upon community targets.

Figure 3.6 hopefully is useful in presenting an overall pattern of the relative strengths and weaknesses of the various steps which are often presented by proponents as their solution to the rail safety problem. This chart shows that there is no one single action that satisfies all the criteria., The chart can perhaps be helpful to any group (such as the federal task force on rail safety) that intends to investigate

Figure 3.6

Evaluation Matrix

Alternative Alleviation Measures

Effectiveness Rating ● Positive ◍ Neutral ○ Negative	Enhance Existing Operations																	Minimize Traffic Impacts							Reduce Dangerous Commodity Traffic							
	Compliance with RTC Orders											Other Measures						Short term						Long term	Ban on DC Traffic	Minimize Excess Movement	Alternative Routings				
	rolling stock retrofit					operating precautions					monitoring & surveillance													land use controls			bypass coridors				
	roller bearings	double shell couplers	head shields	thermal protection	bottom fittings	switching	marshalling	documentation	speed	prior detention		yard safety	running lines	rolling stock	operations	administration	data	scheduling	concentrate loads	confine derailments	confine spills	emergency measures	insurance, compensation				existing	Finch	CN York Sub	Parkway Belt	Northern bypass
Objectives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
improve public safety	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	◍	◍	◍	◍	●	◍	●	◍	◍	●	◍	○	◍	◍	●	●
diminish public exposure	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	●	◍	◍	◍	◍	◍	◍	◍	◍	●	●	○	◍	◍	●	●
avoid shift from rail to road	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	○	●	○	◍	◍	◍	◍	◍	◍
enhance rail competitive efficiency	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	○	◍	○	◍	◍	◍	◍	◍	○
enhance local industry	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	●	○	○	○	◍	◍	◍	◍	◍	◍
avoid shifting hazard to other municipalities	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	◍	○	◍	◍	◍	◍	◍	◍	◍	◍	○	◍	●	○	○	◍	○
cost effectiveness	●	●	●	●	●	●	●	●	●	●	●	◍	◍	●	●	○	◍	◍	◍	◍	◍	●	◍	○	◍	●	●	○	○	○	○
community compatibility	◍	◍	◍	◍	◍	◍	◍	◍	○	◍	◍	●	◍	◍	◍	◍	◍	◍	◍	◍	◍	●	●	○	◍	◍	○	○	○	●	◍

intensively one or more of these measures, and indicates that no one specific action should be selected as the answer.

Other comments on this chart, in terms of relationships and findings, are made as follows:

- Retrofit has been an effective step but does not, of course, affect public exposure.

- Some of the better solutions appear to be: yard safety improvements, density controls (in the long run), upgrading rolling stock (i.e. containers), surveillance measures, the Parkway Belt, a DC storage policy, operations enhancement, DC traffic ban, minimization of excess movements, a northern bypass, and an effective emergency measures plan for the rail corridors--these all deserve further investigations.

Nevertheless, it should be stressed that this is strategic overview, and the level of investigation does not permit final conclusions to be drawn. At best, this analysis can direct more intensive attention to areas of likely advantage.

CHAPTER 4

A STRATEGY FOR TORONTO

This assignment has been referred to as a strategic overview. That is, it does not provide a rigorous examination of a specific aspect of the subject, such as a risk analysis or a route relocation plan. Instead it deals with a wide range of relevant subject matter somewhat in the manner of a lawyer preparing a case. This is an apt analogy because there is no clear cut technical finding or recommendation coming out of this review. The information is presented to the jury--City Council, the media, citizens groups, etc, to make value judgments and decisions as to what future action is best for the community.

Chapter 4 is provided as a final summing up of the evidence with guidelines and recommendations for policies and programs in this subject area

4.1 - OVERVIEW OF FINDINGS

Initially we wish to summarize by chapter as follows what we see as the most relevant findings of our investigations.

Chapter 1 - A Growing Concern

- The implementation of a major vehicle retrofit and rail safety program took place in Canada following a major rail DC accident--the Mississauga derailment.

- Accidents on Canadian railways have been declining since 1981. Rail safety performance in the Toronto area has been good.

- Rail transport has a higher safety record than truck transport, i.e.

	Rail	**Truck**
Percent freight tonnage	38	16
Percent total fatalities and injuries	6.6	68.4
Percent DC related fatalities and injuries	8	60

Chapter 2 - How Present a Danger?

- More than 90% of DC/SDC traffic in the Toronto area travel on east-west CP Rail lines (i.e. North Toronto, Galt west, and Mactier subdivisions).

- Traffic on heavy DC lines (e.g. North Toronto subdivision) carry less than 50 trains per day and no more than nine DC-carrying trains per day.

- The three most commonly carried DCs on rail lines in Toronto are propane, a compressed flammable gas, styrene (a flammable liquid) and methanol (a flammable, poisonous liquid).

- Consistent year-by-year patterns and trends in the transport of DC's or SDC's are not apparent on rail lines in Toronto.

- Approximately 80% of DC and SDC shipments on Toronto railways are trips passing through the Toronto CMA.

- Out of possible DC hazard incidents, three have been identified as being significant in terms of combined probability and consequence--pool fires, BLEVEs and toxic gas releases.

- The probability of one of these occurring within Toronto is once in 800 to 1500 years.

- A number of factors could influence accident forecasts (size of accident, use of containers, DC storage practice, and trespassers or vandals.

- The extent of influence of these three incident types within Toronto could pose a threat to from 700 to 20 000 persons in Toronto neighborhoods, depending upon the incident type and location.

- In assessing hazard characteristics along rail corridors, a high and a medium consequence zones were defined. It is estimated that some 16% and 53% respectively of Toronto's population is located in these two zones.

- A hazard profile was prepared for rail corridors assessing the combined effect of rail facilities and demographic and physical characteristics on hazard potential. This identified the concentration of relatively high hazard levels on those rail corridors combining accident probabilities, DC/SDC traffic levels and accident vulnerability conditions. These sections include the:

  North Toronto subdivision,
  Galt subdivision at West Toronto yard,
  Mactier subdivision.

- These relatively special hazard sections also carry the highest levels of through DC/SDC shipments.

- It is recommended that the special hazard sections be considered as qualifying for the highest levels of risk management practices.

- The City of Toronto is approving high-density developments along the relatively high hazard corridors.

Chapter 3 - What Can be Done?

- Eight objectives were defined as criteria for assessing measures for enhancing rail safety.

  - to improve the public safety of rail operations,
  - to minimize public exposure to DC/SDC rail transport,
  - to avoid shifting freight traffic from rail to truck transport,
  - to enhance competitive efficiency of rail services,
  - to enhance performance of industrial and commercial enterprise,
  - to avoid shifting hazard to other municipalities,
  - to seek cost-effective solutions,
  - to seek solutions compatible with adjacent community and environment.

- Some 32 measures were identified covering measures to:
  - enhance rail operational safety,
  - minimize impact of operations,
  - minimize exposure to DC/SDC traffic.

- Operational constraints in some cases can represent diminishing safety returns in relation to costs and operating efficiency.

- An evaluation of measures was presented showing their tradeoff in relation to safety objectives.

4.2 - KEY ISSUES

In a final review of the question of rail safety in Toronto, a number of key issues present themselves. These are discussed as follows.

4.2.1 - Level of Hazard

A critical question for this study, upon which most key factors devolve, is whether the present and future degree of hazard to which the City's population is subjected as a result of rail and DC traffic, is, in fact, acceptable or unacceptable in the eyes of the public--private and official. If the response is the former one of being acceptable, then the whole question of risk management drops from the critical to the routine. Like most questions in this subject, there are few definite answers.

In assessing this question, four aspects of hazard in Toronto present themselves:

- The low probability of rail accidents,
- the possibly heavy consequences of such accidents,
- the likely uncertainty characterizing the anticipated future levels of accident,
- the apparent concentration of rail DC hazards in densely populated areas with conditions of accident vulnerability.

Following are comments on the above matters discussed in Chapter 2:

Probability and Consequences. Listed below are the three critical* DC hazard events identified for Toronto, along with their respective probabilities (assuming complete tank car release) and impact consequences for typical area of Toronto.

---

* 'Critical' reflecting the combined measure of both probability of occurrence and scale of consequence or impact.

Pool Fire	Probability (once every)	Lethal Zone (radius in ft)	Maximum Population Possibly Affected
Pool Fire	1 500 to 3 400 years	630	1 200
BLEVE	9 100 to 20 000 years	620	8 000
Toxic gas release	1 300 to 3 800 years	2 000	20 000

Uncertainty. Because of anticipated uncertainty in a number of factors, the foregoing probabilities and consequence levels could vary under future conditions, i.e.

- Likely changing patterns of DC/SDC demand, leading to higher or lower traffic levels.

- Probability estimates are based upon a variety of data sources which affects the accuracy of probability estimates.

- Assumptions in the incident analysis include the total escape of substance from the tank car. This produces an estimate of the highest consequences and the lowest probability. A lesser release would result in higher probability levels and lower consequences and thus numbers of persons threatened.

- Uncertain performance of tanktainers in lieu of international engineering standards being less than those of tank cars.

- Possible accident aggravation associated with uncoordinated approval of DC storage in vicinity of rail corridors.

- Difficulty in controlling trespassing on rail rights-of-way.

Concentration of Hazard. As has been discussed in Chapter 2, Section 2.8 on hazard profile, negative hazard features tend to concentrate on certain rail sections in Toronto:

- higher accident probabilities,
- higher population/employment concentrations,
- vulnerable institutions and services,
- evacuation difficulties.
- certain topography problems (i.e. catchbasins).

All of the above factors tend to aggravate the hazard potential of these sections, and to increase the likely consequences of the accident.

Almost 40% of the City's population is located within the consequence zones of those rail subdivisions carrying over 90% of the DC/SDC loads carried within Toronto.

Based upon this discussion and the information provided earlier in the report, Council must judge how critical this level of hazard is in relation to accepted conditions of public safety in Toronto. This will govern how urgently measures to optimize rail safety or to remove dangerous loads from proximity to neighborhoods will be pursued.

4.2.2 - Need for Diminishing Exposure

The issue of public exposure to hazardous goods traffic cannot be separated from the question of acceptable levels of hazard. If high priority is assigned to hazard alleviation, then decreasing public proximity to hazard must also receive close attention. In Vancouver it was decided to remove the hazardous goods from proximity to population concentrations regardless of probability estimates.

As mentioned above, the DC traffic hazards are essentially confined to a limited number of subdivision corridors (i.e. North Toronto, Galt and Mactier subdivisions). Listed below in Table W are estimated numbers of population elements located in the consequence zones of the above subdivisions.

TABLE 4.1

Population Element	Population Exposure	
	MCZ*	HCZ
Resident population	233 825	51 546
Employment	85 233	31 407
School students	38 396	11 196
Hospital beds	2 622	742
Special institutions (i.e. college students)	5 333	5 333

*** MCZ data includes that of the HZC.**

Where exposure is considered excessive it can be mitigated by both operational and developmental measures. That is, either by diverting rail traffic and/or introducing land use controls. Both of these risk management measures are discussed above in Chapter 3.

Another consideration in this issue concerns land use development along the relatively high hazard corridors. A number of photos are enclosed which show recent high density developments at rights-of-way of the Galt and North Toronto subdivisions (high rise apartments, multiple use, shopping centers, senior citizen residence). Currently a major multiple-use development of the Massey Ferguson property on the Galt subdivision is under review for approval. This is situated adjacent to a rail line carrying over 700 car loads of DCs per month.

This places the City in a dilemma concerning approvals for existing and proposed sites. On the one hand, possible lower densities for corridor land uses would represent a form of economic penalty to the City. Conversely, if the rail traffic is not diverted, how can the City accommodate the earlier decision to accept high densities in the HCZ.

These two questions--first, the existence of high populations in the consequence zones of relatively special hazard sections, and secondly, the matter of high density developments existing or proposed in the HCZ of these lines--must be considered carefully in considering the goal of minimizing public exposure. If this is considered an essential objective, then the bypass option receives an impetus.

4.2.3 - Operational Constraints

In the discussion of risk management measures in Chapter 3, a variety of operating constraints have been included, extending from speed restrictions to network management arrangements. Many of these are hindrances to the efficient or competitive operation of the rail service.

The measures enforced by RTC order on Canadian railways following Mississauga derailment show-cause hearing were all operational constraints of one type or another. For instance

- speed controls,
- inspection measures,
- train marshalling regulations,
- humping operations constraints.

These regulations represent incursions upon rail operations in urban areas representing cost and operating constraints. They have undoubtedly had a signal effect upon reducing rail accidents, although some measures have been more effective than others.

It is recognized from the records that such measures have made a major contribution to recent safety improvements. As well documented by the railways, such actions while beneficial in terms of safety have represented costs and constraints affecting rail operating efficiency and competitiveness.

The conclusion we wish to make, is that by concentrating on purely operational solutions to safety, we are likely to be moving further into a situation of diminishing returns and increasing costs. That is, a condition where for increasing costs and service constraints we are likely to achieve lower safety benefits. As recorded in the literature, there is a component of accident cause (human error, external causes, etc) not affected by operating measures. It is suggested that if the above is the case, then we are justified at looking at measures other than operational constraints for future risk management. A number of those listed as appropriate in Chapter 3 would fit this category, i.e.

- bypasses or diversions,
- land use controls,
- emergency response plan,
- DC storage integration,
- advanced technology systems.

4.2.4 - Seeking a Balanced Solution

The federal Railway Relocation and Crossings Act governing the preparation of urban rail rationalization plans stipulates that only "no-lose" schemes will be acceptable. That is,it is intended that neither the carriers nor the community will suffer financially or otherwise. A similar planning objective for a rail safety program should be adopted.

There would appear to be a number of positive factors to be considered in developing an acceptable risk management approach.

- As outlined in Chapter 2, p.75, over 80% of the DC/SDC traffic on the North Toronto subdivision is through traffic. That is, traffic that is neither originating in or destined for the Toronto CMA. As such, it can be considered eligible for diversion for a possible future bypass. Any future studies of bypass (i.e. rerouting) alternatives can assess possible opportunities for rail benefits in the form of high-speed routes bypassing the Toronto area.

- The North Toronto subdivision a double-track main line with superior rail-service features for frequent rail operation. This line represents a key rail link in the Toronto network with a direct, high-standard connection between the Toronto and Lambton yards. Any bypass planning (rerouting) would examine the possible rail use of this route. One possible service option would be its use by GO Transit for access to the Summerhill Station from the Don Mills and the Scarborough areas, and/or Mississauga. Such a prospect would be a timely consideration in light of current investigations of rapid transit service in this corridor. (See discussion, Section 4.2.5)

- An important consideration would be the need for a long term solution. That is, one where public exposure to DC traffic would be minimized -- i.e. a protected corridor.

4.2.5 - Impact on Railways

Of the various risk management actions suggested as advantageous for enhancing safety, only three directly affect rail operations. These include

- rail bypass of Toronto CMA (rerouting)
- enhanced yard safety
- speed restrictions.

These are discussed below in terms of their overall affect on rail operations.

- Bypass Options - As shown in Figures 3.2 to 3.5 proposed bypass options generally don't represent major distance extensions to CP operations. It is conceivable that higher operating speeds would offset any likely time losses. (Assuming speed restriction would be rescinded for rail lines in open country or a protected corridor.) Bypasses would be connected to major classification yards such as the CP Toronto Yard in Scarboro. Bypass routes would provide direct access to the northbound Mactier subdivision serving western Canada and northern Ontario.

  At this point, some comments can be made about the possible use of a bypassed CP east-west corridor (North Toronto/Galt subdivisions). There has been considerable review recently of rapid-transit service in the Metropolitan Toronto area. However, the use of this east-west rail corridor has not been considered because of its current and apparently permanent heavy use by freight traffic. In the event of capacity becoming available, there are favorable aspects of passenger transit use that bear investigation.

  East of Yonge Street - This rail corridor feeds directly into the Summerhill station of the Yonge subway line. The North Toronto subdivision could enable GO-train service from the CN Bala subdivision and the CP Belleville subdivision to provide direct access to the Yonge subway from areas of Scarborough and Don Mills with low levels of transit access. This would also cover a major catchment zone designated for the proposed Downtown Access Subway Line and as such defer construction of this costly facility.

  Such an easterly service could relieve the Yonge subway capacity constraint, which is to some extent a result of the passenger congestion at the Bloor station, which impedes the use of closer headways thereby achieving increased peak period capacity.

West of Yonge Street - A major planning concern in the Toronto CMA is the need for increased passenger capacity across the Humber River into Mississauga. This rail corridor could provide an additional opportunity to meet this demand by running service from central and northern Mississauga through to the Spadina and Yonge subway lines.

The above opportunities for passenger use of the CP east-west route merit closer investigation and assessment as part of the federal Task Force assignment.

- Enhanced Yard Safety - Several yard operations occur along the relatively high hazard zone (i.e. Lambton, West Toronto (CP and CN) and Leaside yards). A priority therefore is to take every step to ensure safety in these sites, with particular emphasis on emergency response mechanisms. Currently railway and MTEPAC staff are coordinating in developing procedures for handling dangerous incidents on rail lines. This should be accelerated with special attention to yard operations and covering the following steps:

  - Developing emergency response plans for yard incidents.
  - Carry out exercises on simulated incidents in yard operations (recent Moore Park exercise provided successful example of coordinated operation),

  - Establish effective procedures for notifying municipal authorities in the case of DC accidents.

  - Establishing procedures for informing MTEPAC staff concerning substances stored in yards or in the vicinity of yards in the case of either a DC incident or prolonged storage of DC carloads (in the latter case RTC permits are needed for storage over 48 hours) either on line or on an industrial siding. (Provincial Bill 101 is expected to provide for recording private DC storage).

In conclusion, it should be noted that this report deals with a wide range of existing and possible constraints on railway operations. An objective viewpoint might consider this one-sided since DCs are handled in many other modes in the City--marine, truck, air, pipeline transport, service stations, industry, etc. It should be recognized that a comprehensive rail safety program can only be meaningful if accompanied by safety programs, equally vigorous for other DC venues in the City, with particular emphasis on the truck mode, and the subject of DC storage.

Service to Industry - There are a limited number of sites in the City of Toronto where the CP delivers directly to industrial locations. The intent is that risk management measures would not interfere with any rail access to local industry. By removing through rail traffic from the east-west route made up by the North Toronto/Galt subdivisions, the movement of transfer and switching traffic would be facilitated, and possible opportunities for additional industrial access sidings could be accepted.

Speed Restrictions - In the discussion in Chapter 3 on the effects of operating speed restrictions, the recognized safety advantages are noted as well as the operating constraints and penalties. In considering the effect on delivery time, railway officials report that, in most cases, the key service factor is dependability rather than actual speed of delivery. In most transportation modes, the effect of lowering operating speeds and thereby increasing the time per trip, is to create a need for more rolling equipment.

In considering the effect of speed restrictions on rail operations on an urban subdivision, it could be assumed that the overall effect on a long trip (>100 miles) might be insignificant.

However, it could have the effect of adding crew runs and thereby adding train crews and thus costs to operations. The railways should provide clear estimates of likely staffing, costing and operating effects in any assessment of this question.

4.2.6 - Impact on Community

Section 4.3 below deals with the specific effects of risk management measures on city administrative functions. In this section, we wish to discuss in general terms the likely positive or negative effects of an intensive risk management program upon the City of Toronto.

If an effective and permanent risk alleviation program (e.g. DC/SDC diversion) can be put into effect, Toronto will definitely benefit in the long term from the removal of the threat of chemical incidents resulting from rail accidents. As a result, the rail network within Toronto could experience a functional change from a combined through freight and local delivery role, to a purely local service. This will, to a large degree, diminish the noise and vibration levels experienced along the North Toronto subdivision, as well as much of the hazard on that route. Hazard relief will occur as well on the Mactier/Weston subdivision and the Galt subdivision west of the West Toronto diamond. It should be noted that little hazard alleviation will occur on the Galt/Weston corridor (Lambton to Parkdale), since little through traffic uses this link. For this reason the risk management program should not depend on one specific measure (e.g. the diversion option), but should ensure that all relevant steps are taken to maximize rail safety for the remaining DC flows.

A key step would be to develop a comprehensive emergency response program for this Galt/Weston corridor. As well, consideration should be given to constructing an overpass at the Strachan Avenue level crossing.

Another benefit from the diversion of through DC traffic to a bypass facility would be an accompanying lessening of the threat to natural amenities, particularly in the case of the three ravines at the east end of the North Toronto subdivision, feeding into the Don River.

It does not appear that the change in function of the Parkdale Yard from a marshalling to a multimodal facility would free any property for land development. Conversely, if a major diversion of traffic from the North Toronto, Galt west and Mactier subdivisions were to occur, then it is possible that the reassembly function of the Lambton and West Toronto yards would shift to a transfer and switching role, with the possibility that lands could be available for redevelopment.

As discussed earlier, another potential opportunity to the City could result from the possible use of the North Toronto subdivision for passenger rail service -- i.e. GO trains serving the Spadina and Yonge subways from the east and west. This may have definite financial advantages to the City as a result of the minimal capital and operating costs of a GO train service compared to proposed subway lines which may be relieved or postponed by such a service (i.e. Eglinton and Downtown Relief subway lines). Any opportunities for passenger service along this line could be considered as a possible exchange strategy between the various parties involved in the implementation of a feasible bypass route.

4.2.7 - The Task Force

In March 1986, the federal Minister of Transportation authorized the Toronto Area Rail Transportation of Dangerous Goods Advisory Council. this group was assigned an undertaking to investigate the three topics of:

" (i) the feasibility of re-routing rail traffic transporting dangerous goods within the Toronto area;

(ii) the feasibility of relocating rail transportation services carrying dangerous commodities within the Toronto area;

(iii) the feasibility of additional requirements governing the transportation of dangerous goods by rail...."

The Terms of Reference as well include references to those elements clarifying and quantifying the above objectives including:

- costs and benefits,
- impacts,
- implementation requirements.

It is hoped that this strategic overview will provide a useful preliminary assessment for the guidance of the Task Force. Later in this chapter, a set of recommendations is included directed at the program of the Federal Task Force and reflecting what we see as the main City concerns in relation to that study.

4.3 - STRATEGIC OPTIONS FOR THE CITY OF TORONTO

The following discussion of strategic options which allow the City of Toronto to take direct action on the DC issue is limited to those which do not affect the operations of the railways. Matters touching on rail line location and railway operations are beyond the aegis of the City; its influence in these issues is limited to persuasion and lobbying of the railways and higher levels of government.

Direct action on rail DC rerouting or line relocation is very much in the future. The present Federal Task Force studying these options is not expected to publish its final decision until March 1988. If rerouting of shipments is necessary, planning and construction would require at least another three years. Full relocation of even the North Toronto subdivision would require upwards of five years.

The upshot of this is that regardless of the decision of the Federal Task Force, the City is faced with a lengthy period in which the present situation will prevail. It is in this hiatus where the City must concentrate its efforts. A number of policy options exist, and are discussed below. The chief characteristic of these suggestions is that action can be taken without delay.

4.3.1 - Land Use Control Measures

Zoning

As was discussed at length in Section 3.2.2, the recognition of a public safety hazard through the passage by rail of DC shipments through the City presents the City with a dilemma concerning land use and development policy. On the one hand, we have large numbers of resident, employee and student populations within the consequence zones of rail lines (up to 50% across the City). As well, a number of high density and, in some cases, multiple-use developments are located or planned in direct proximity to special hazard sections.
On the other hand, the City is faced with the reality that certain land uses are incompatible with the proximity of volumes of DC/SDC shipments transported by rail. Under such circumstances, revisions to current zoning By-laws may be required along these corridors.

The City's response must be governed by the possible alternative events occurring in the future, i.e.

- the diversion of through DC/SDC traffic to routes outside of Toronto,

- the diversion of large amounts of all types of through rail traffic to a bypass route around the Metro Toronto area,
- the status quo where prevailing rail traffic levels remain on the presently used rail lines within Toronto.

The land use zoning factor should be an important input to the decision on the above options. In fact, it may be the most critical argument for the diversion of DC/SDC traffic. Nevertheless, the City is faced with a dilemma concerning the extent of changes needed to zoning By-laws, both in the short-term and the long-term. In fact, it is perhaps too late to rezone the land in the HCZ since there are numerous high density developments now in place or under review. This subject may provide the strongest argument for dangerous goods diversion. As was recommended in Chapter 3, City staff should review this question and define land use control measures appropriate to the different DC transport scenarios for implementation on the resolution of long-term transport plans.

4.3.2 - Emergency Response Planning

Since the City has no control whatsoever over rail operations, it cannot act to reduce the risk of a DC accident. What it can do, and at great profit to all concerned, is to set about improving its ability to deal swiftly and wisely with such incidents.

The representatives of MTEPAC, the Metropolitan Toronto emergency measures body are listed in Section 3.2.1.e. MTEPAC has a small permanent staff, but the intent is to develop a close working relationship with all affected organizations.

The two departments most closely involved with emergency measures are, by their nature, the fire departments and the Metro Police Force and Department of Ambulance Services. Each has their specific resources, data and skills, and the intent is that they work closely together in preparing for and responding to emergency situations.

As well, both the railways, the trucking and chemical industries have formed and equipped expert teams specially trained to deal with particular DC accidents, equipment requirements, and spill containment, neutralization and clean up. It is essential that in this area these bodies coordinate their work with the MTEPAC body and assist them in developing integrated emergency response plans for rail facilities in this area. Topics for consideration by these groups include notification, cooperation, sharing of information and equipment, training, on-site security, and command relationships.

An integrated effort between all active bodies is essential in order to ensure optimal plans and execution, reduction of duplicate or parallel efforts, and clear lines of communication and understanding between participants.

A key area of emergency planning in which the City may take an initiative is in the development of a data bank, readily accessible by industry and government, listing the type, quantity and location of dangerous commodities within the City. This has several dimensions:

(a) Railways in an emergency should inform of any DCs located in rail yards within the City.

(b) Industries receiving or shipping DCs by rail in an emergency should inform the City of their type, volume and location.

(c) Industries storing quantities of DCs in volumes above a certain threshold should inform the City of their type, quantity and location.

In the case of (a), RTC regulations require the railways to have this information available. In the case of (b) and (c), the proposed Provincial Bill No. 101 is intended to make these steps mandatory.

The purpose of this data would be to allow emergency response officials to know, without having to do a local reconnaissance, what complications a fire, on or off the railway, may cause in nearby industrial properties. This data base should not necessarily be limited to the areas around the rights-of-way. It could have beneficial effects for response to fires in other emergencies on a City-wide basis.

Finally, a major objective is that the MTEPAC prepare an overall plan for emergency response on rail lines across the City and address such factors as:

- a prioritizing of emergency measures in relation to the extent of hazard potential identified for each line,

- a focus on the special problems of rail yards,

- a series of evacuation exercises in selected City areas.

4.3.3 - Rail Corridor Security

Just as cooperation is desirable between public and private agencies in emergency measures, so it is possible in increasing rail corridor security.

Although there is evidence of considerable trespassing taking place, experience to date in Toronto has shown minimal accidents attributable to vandalism by rail trespassers. A recent exception occurred when a train was derailed on the North Toronto subdivision as a result of a piece of rail placed on the tracks. Fortunately the train was slow moving. Few occur across the continent. In 1978 a severe chlorine spill was caused by vandals in Florida.

It is true that much of the responsibility for security on railway property falls on the railway police forces. In common trespassing areas Metro Police maintained special surveillance and enforcement. Along the special hazard areas the City and railways should consider implementing special measures for controlling possible vandalism. For example, the City should consider cooperating with the railways to share the cost of constructing walls around active yards and some of the busier sections of the main line. At present, protection is provided only by chain-link fences topped with barbed wire. This type of fence can be cut or squirmed under. Walls or other forms of barriers would certainly act to discourage such behavior. Electronic protection measures could be considered, as well as fines or penalties. As well, the City can consider alternate pedestrian crossings to rail rights-of-way short cuts.

4.3.4 - Approaches to Other Levels of Government

Whatever measures the City of Toronto decides to pursue concerning risk management of the movement patterns of DCs by rail, it must carefully consider its approach to the governing bodies. The Ministry of Transportation and the Railway Transport Committee have, for the time being, placed the issue in the hands of the Federal Task Force. Until this study is complete, major action cannot be expected from either of these sources.

The Task Force's chief consideration will be to discern whether the level of risk is adequate to justify the massive expenditures required. Care will also be exercised that the railways are not financially or competitively penalized. Within this context, the City must develop its presentation to the Task Force to reflect a real concern for these provisos.

The provincial dimension in this scenario cannot be ignored. Removal of DC shipments, much less wholesale relocation, would be stridently opposed by suburban municipalities. Under the "Railway Relocation and Crossings Act', provincial approval is a precondition of RTC approval. Consideration will have to be given to soliciting provincial favor for the City's goals, should substantial alterations to the status quo be suggested.

Clearly, no advances will be made unless the strategies selected develop as a result of an overall assessment of existing political, social and economic conditions and potential solutions, involving financial, safety, land use and community planning, transportation, and environmental impacts.

4.3.5 - Implications of Suggested City Strategies

Industrial

In pursuing a policy of rerouting DCs, or of relocating the CP main line, the City must first give very careful consideration to the possible conflict between such an action and existing policies to retain industrial activity and employment.

Any rerouting scheme, as with additional operational restraints, must strenuously avoid causing delays or unreliability in the delivery of shipments to DC consumers in the City. Unnecessary friction could lead to industrial relocation.

This is a particular danger with relocation schemes. Not only might the prospect of delivery problems cause industrial relocation, but the opportunity to get direct rail access to a modern line in undeveloped land might also cause a loss of industry.

City staff should carefully consider the sensitivity of local industry to changing delivery schedules and most of all, to cheap and readily accessed land. Without further study, any decision to continue advocating the relocation of CPs main line functions on the Galt and North Toronto subdivision may have unpleasant repercussions for the City's industrial base.

Financial Implications

A wide range of risk management measures have been reviewed. Each has its cost. Without attempting to deal with this extensive subject in any depth, one can make the following general comments on the range of obligations to the three main parties affected--the railways, higher levels of government, and the City of Toronto.

Railways. The railway industry, which includes the various owners and leasers of rolling stock, have since 1980 invested considerable funds in carrying out the many actions ordered by the RTC after the Mississauga Show Cause Hearing. Obviously the bulk of the equipment and operating actions and constraints will largely be borne by this sector. Certainly any intensive assessment of measures proposed by this study or the Federal Task Force must assess the resulting cost effects, which will include not only the direct capital or operating costs but the external costs of related operational expenses, plus the losses incurred including market losses, etc. Conversely some benefits will occur, for example, savings in the form of declining accident costs.

There is no doubt that the extra expenditures will be substantial, and the authorities will need to assess their impact on the railway industry's competitive position and operating efficiency.

Higher Levels of Government. These refer to the Federal Government and the Province of Ontario. It might be assumed that any financial contribution from these authorities would cover major capital expenditures likely associated with traffic diversion.

Under the currently inactive UTAP program (Urban Transportation Assistance Program) the federal government had stipulated certain formula for financial assistance for rail relocation schemes, as designated in the Railway Relocation and Crossings Act. It has been suggested that the federal government at present may act in an ad hoc fashion in response to an apparent need.

There is little precedent for a Province of Ontario contribution to the financing of rail freight lines in southern Ontario, although the provincial government has participated in numerous railway operations (e.g. GO Transit, the Ontario Northland Railway). In recent years the Province has funded the assembly of a parkway belt corridor around the north boundary of Metro Toronto. Development of a protected corridor concept for the movement of publicly and environmentally dangerous commodities could perhaps be considered a valid extension of this policy.

A major diversion scheme would require a massive engineering undertaking, requiring potentially difficult land acquisition. Capital expenditures for the diversion concepts described in Chapter 3, would undoubtedly be high--in the hundreds of millions or higher. Undoubtedly, it could only be undertaken by means of some cost sharing formula, likely involving the federal and provincial governments, the railways, and the municipalities affected.

City of Toronto. It is unlikely that the City would be expected to contribute to any railway mechanical or operating expenditures. In the case of capital funding for a diversionary scheme, the City might be expected to contribute, probably as part of a Metro Toronto contribution. It might be prudent for the City to anticipate the possibility of such an obligation.

In the case of the various other means for enhancing risk management, there appear to be a variety of areas where a municipal outlays or losses could be expected, i.e.

- special measures for ensuring security along rail rights-of-way,
- losses from restrictive land use zoning along rail corridors,
- expanded emergency response measures,
- possible industrial losses from diverted services,
- possible transfer of higher level funds from other programs.

The key point of all these options is that safety costs money. One essentially 'buys' reductions in the risk of a DC accident, or its consequences. This always involves direct and indirect costs, the allocation of scarce resources, and can radically alter the complexion of the local land market. City staff are advised to study carefully the potential economic outcomes of any final proposals or decisions in this area.

4.4 - AN INTEGRATED PUBLIC SAFETY PROGRAM

We live in a period of the proliferating development and manufacture of industrial chemicals and substances. The current study is a response to a community concern over the perceived increasing danger of transporting dangerous chemicals. As the preceding section has documented, action by a variety of authorities is needed to deal with this hazard.

In focusing on the specific role of the City in addressing this concern, we wish to stress the need for developing a City-wide integrated public safety program. It is apparent that the rail industry operates efficiently and safely in providing a service to industry. It is also apparent that the municipality must assure a high degree of responsibility for ensuring public safety associated with DC transport within its boundaries. For this function we recommend that the City maintain an integrated public safety program for rail safety inside Toronto. Such a program will cover the following components.

(a) Promoting a Prioritized Risk Management Strategy

Since the analysis outlined above has indicated a hierarchy of hazardous conditions along the various rail sections within Toronto, we recommend that a prioritized approach to investment and action be applied to those sections having the highest relative levels of hazard.

We recommend that such an approach be used by all parties involved in rail safety, including the railways, so that operational and mechanical safety measures be applied to special hazard locations. This will, of course, ensure that the investments in rail safety will achieve the greatest return in operational safety and public protection.

(b) Land Use Control

This subject has been discussed in Chapters 3 and 4. Generally speaking, this step entails regulating land use in order to minimize accident impacts and to facilitate area evacuation and site access by emergency vehicles. This topic presents the City with difficult decisions related to the probable form of final resolution of the rail safety question particularly involving the possible diversion of DC/SDC traffic. To what extent should the City inhibit development along these corridors, both in the short-term and in the long-term?

An important issue associated with municipal land-use control involves the storage of DCs in the vicinity of rail rights-of-way. It is imperative that City staff in cooperation with provincial and RTC officials address the question of achieving an orderly location of DC storage, and an integrated process of approving new DC storage sites.

(c) Rail Rights-of-Way Safety

It is essential that the respective authorities in the City, Metro Police, the railways work together in rectifying the present circumstances of widespread trespassing of railway property in special hazard sections. An effective program would involve a combination of surveillance, physical separation or barriers, alternative pedestrian passageways, penalties and public information.

(d) Emergency Response

The mechanism exists for an effective emergency response program in the form of the MTEPAC structure and the attitude of cooperation from other parties including the railways. Effective action in the occurrence of serious rail incidents may possibly be the most advantageous risk management measure in terms of preventing injuries and fatalities. An immediate priority must be to prepare an adequate community-wide emergency plan for all rail lines in Toronto. Again this plan should reflect a prioritized approach to sections of relatively special hazard. The final program should stress:

- close involvement of railway and provincial forces,
- effective population handling, evacuation exercises, etc,
- centralized and integrated control.

(e) Information Systems

This subject is discussed earlier in Chapters 3 and 4. A key area is the availability of data prior to and in response to rail accidents. This involves:

- incident notification,
- DC storage documentation (including yard information),
- consist documentation (by train crew and on-line computerized records),
- substance emergency performance data.

Another important data concern arises out of the apparent significantly changing patterns of DC/SDC transport year-by-year along Toronto rail lines. Under these circumstances we believe that municipal emergency forces (i.e. MTEPAC) must be aware of these patterns in order to assess hazard levels, locations and the nature of prevailing substance movements during a given period. Accordingly, we recommend that the RTC make available to MTCPAC, on a yearly basis, the classes and amounts od DCs carried on individual subdivisions in the Metro Toronto area. This information would be provided on a confidential basis in order to preserve corporate marketing information security.

4.5 - RECOMMENDATIONS

In the foregoing a wide range of possible actions, policies or programs were discussed as possible measures for the management of risk on rail subdivisions in the City of Toronto. We have listed below those specific steps which we feel are justified under the apparent conditions of rail operations and hazard. These range from specific constraints or actions which we feel are justified in the interests of safety to those areas of further investigation that are called for. We have classified these recommendations in terms of:

1. Immediate or short-term actions.
2. Long-term actions.
3. Operational or administrative recommendations.

In dealing with short-term actions we have divided these into actions prioritized to apply to special hazard areas and those applying to all routes.

1. Immediate or Short-Term Measures

Special Hazard Sections. These have been designated in the hazard profile assessment (Chapter 2) to include the North Toronto, Mactier, and Galt (west of West Toronto Diamond) subdivisions which justify special safety measures including the following recommendations.

(a) That the Province of Ontario (Ministry of Transportation and Communications) and the City of Toronto request that the Government of Canada ensure that the request to Treasury Board be met for the provision of additional RTC inspectors for monitoring and surveillance of rail operations in the Toronto Region.

(b) That the City of Toronto request the RTC to investigate the best means of eliminating or sharply curtailing the through movement of SDC tank cars on the Toronto Terminals Railways.

(c) That the City of Toronto request the RTC, in cooperation with the railways, to investigate the use of extended Jordan Guard Rails to confine derailments in special hazard sections.

(d) That the City of Toronto request that the railways, working with Metro Police, develop a program of special security measures to discourage trespassing and vandalism on rail rights-of-way on special hazard sections.

(e) That the City of Toronto request the RTC to apply speed restrictions proposed by the Federal Task Force, following their assessment of their effects, to the special hazard sections as required.

(f) That the MTEPAC organization recognize the needs of the special hazard sections of the City's railway lines and yards and ensure that response procedures are in place.

Overall Rail Network in Toronto

(g) That the City of Toronto request that the Province of Ontario (Ministry of Transportation and Communications) and the Government of Canada (Transport Canada) approve the construction of a grade separation at the Strachan Avenue level crossing.

(h) That the Province of Ontario (Ministry of Consumer and Commercial Relations) and the RTC, working with the City of Toronto, establish effective authority and procedures for the control of bulk storage of DCs on private lands adjacent to rail corridors.

(i) That the Province of Ontario (Ministry of Labor) effect suitable legislation to ensure the availability of information on the storage of DCs for use by municipal emergency response personnel.

(j) That the MTEPAC organization in planning and effecting emergency response measures work closely with the railway companies, the RTC, the chemical industry and the trucking industry.

(k) That the City of Toronto (Department of Planning and Development) investigate suitable short-term land use regulatory measures for rail corridors.

2. Long-Term Measures

(l) That the City of Toronto (Department of Planning and Development) following the resolution of long-term plans for rail DC traffic in the Toronto area, establish suitable land-use regulatory measures for rail corridors.

3. Operational and Administrative

(m) That the City of Toronto request that the RTC set a high priority on assessing the need for safer engineering standards of containers and supporting vehicles for DC transportation by rail.

(n) That the Government of Canada and the railway companies pursue with all deliberate speed the possible use of Advanced Train Control Systems on special hazard sections in Toronto.

(o) That the Government of Canada (Transport Canada) investigate the provision of rail system operating data for use in emergency response planning and the general investigation of DC rail transport in urban areas.

(p) That the City of Toronto request that the RTC assess the potential advantages of operating designated DC trains in built-up areas, including the effect on public safety.

(q) That the City of Toronto request that the Government of Canada (Transport Canada) rationalize and amend the current list of DCs and SDCs.

(r) That Metropolitan Toronto, in cooperation with City authorities, prepare a plan for the safe operations of DC transport by truck in Toronto.

(s) That the City Department of Planning and Development investigate the impact of rail risk management measures on industries in Toronto.

(t) That the RTC investigate thoroughly whether any specific operating treatment for empty tank cars previously carrying DCs is justified in terms of operating and economic factors including public safety.

(u) That the City of Toronto request the RTC to assess the interrelationship of train length and the number of DC shipments present with specific attention to public safety.

(v) That the RTC ensure that rail operating data indicating changing traffic levels of categories of DC/SDCs in this area be provided to MTEPAC and the City of Toronto Fire Department on an annual basis for the use of emergency response personnel.

4. Recommendations to the Federal Task Force

We wish to make the following recommendations concerning the further analysis and deliberations of the Toronto Area Rail Transportation of Dangerous Goods Advisory Council.

(w) That a prime objective of the Task Force's research should be to establish a long-term or permanent solution concerning public exposure to rail transport of dangerous commodities, possibly in the form of a protected rail freight corridor. A protected corridor should be of suitable width and/or contour to protect adjacent communities from DC incidents.

(x) That the rerouting options described in Chapter 3 of this report be considered for possible intensive assessment.

(y) That the overall justification and necessity for a major rerouting option be determined. This would include, in addition to operational and capital financing, the economic costs of current DC traffic levels in terms of land development and public hazard impacts, plus impacts upon industry in Toronto.

(z) That bypass plans be assessed in relation to an overall rail risk management program in the Toronto CMA.

(aa) That the feasibility and impacts be assessed of a possible ban on through DC/SDC shipments by rail in the City of Toronto.

(bb) That the 25 mph speed limit be examined to determine whether it produces significant improvements in operational and public safety relative to the 35 and 50 mph limits now in force.

END NOTES

1 Event Probabilities and Impact Zone for Hazardous Materials Accidents on Railroads, Nayak, Rosenfeld and Hagopian, Arthur D. Little, Inc., August 1983.

2 Generating Hazardous Material Risk Profiles on Railroad Routes, Raj and Glickman, Conference on Recent Advances in Hazardous Materials Transportation Research. TRB, November 1985.

3 An Examination of Canadian Railway Derailments and Collisions, January 1, 1984 to March 21, 1986. Canadian Transport Commission, Railway Transport Committee, March 26, 1986.

4 Association of American Railways HM-144 performance standard.

5 National Transportation Safety Board, Washington, DC, Safety Recommendations I-82-1 through 4. Issued: April 28, 1982.

6 Hazard Analysis of Propane Tank Failures in a Specific Location, Klement and Napier, University of Toronto, January 1986.

APPENDICES

A - A Glossary of Railway Terms

B - Tank Cars and Their Characteristics

C - Probabilities: Process and Assumptions

D - A Guide to Hazard Assessment

E - Topical Bibliography

APPENDIX A

A Glossary of Railway Terms

APPENDIX A

GLOSSARY OF RAILWAY TERMS

Centralized Traffic Control (CTC)

A term applied to a system of railway operations by means of which the movement of trains over routes and though blocks on a designated section of track or tracks is regulated and directed by signals controlled from a designated central point.

Classification Yard

A rail yard consisting of a number of usually parallel tracks, used for the marshalling of trains.

Consist

The number and sequence of cars making up a specific freight train. The general type of contents in each car is also listed, as well as any special classifications, such as DC or SDC.

Container

An independent structural unit, either open or fully enclosed, designed for the intermodal transport of commodities.

Continuous Welded Rail (CWR)

Pre-welded sections of rail installed in lengths up to 1400 feet to provide continuous lengths that can run miles between joints.

Coupler

A device located at both ends of all rail cars and locomotive units, providing a standard means for connecting one rail car or vehicle to another.

Diamond

A track structure that permits intersecting sets of tracks to cross one another at grade.

Hump Yard

A railway classification yard in which the classification of cars is accomplished by pushing them over a summit, known as the 'hump', beyond which they run using the force of gravity. Devices called 'impeders' are used to dissipate some of this energy so that cars will couple within the desired speed range.

Intermodal Traffic

Freight moving via at least two different modes of transport. Containers are customarily shipped in this manner.

Jordan Guard Rail

A rail or other structure laid parallel within the running tracks to prevent the wheels of derailed trucks from moving beyond the outer edge of the ties. These rails may also serve to bounce derailed trucks back onto the running tracks.

Journal Bearing

The general term applied to the load bearing arrangement at the ends of each axle of a rail car truck. These come in two basic types - plain and roller. (see Appendix #2)

Signal

Any of the various devices or displays, commonly colored lamps, used for controlling train movements and for informing train crews of track occupancy conditions.

Subdivision

The basic section of operating rail line; usually runs between junction points or designated mileage points.

Switch

A track structure with movable rails to divert rolling stock from one track to another. These may ne operated manually or by remote control from a central traffic control station.

Switching

Switching service usually consists of moving cars from one track to another or to different positions on the same track.

Symbol (Through) Train

A scheduled freight train which usually travels between major terminals in different urban centers, and is designated by a number code and date. (CP Rail)

Tank Car

A rail car , the body of which consists of a tank for transporting liquids or liquified gases. These cars can be pressurized or non-pressurized.

Tanktainer

An intermodal container deigned to carry liquids or liquified compressed gases.

Transfer Train

A non-scheduled freight train usually employed to move cars between yards or sidings in an urban area.

Waybill

The primary written documentation of each freight shipment, it forms the basis for railroad freight revenue accounts.

APPENDIX B

Tank Cars and Their Characteristics

APPENDIX B

TANK CARS AND THEIR CHARACTERISTICS

Part 1 - How to Read a Tank Car Classification

Part 2 - DOT 105 Tank Cars

Part 3 - DOT 112 and 114 Tank Cars

Part 4 - DOT 103 and 111 Tank Cars

Part 5 - Tank Car Safety Measures

Part 6 - Trackside Detection Sites

End Notes

PART 1 - HOW TO READ A TANK CAR CLASSIFICATION

All tank cars carry a classification number which sets out its characteristics through seven elements, e.g.

	DOT	105	A	300	AL	W	C
Element	1	2	3	4	5	6	7

Element 1 - Agency Authorizing Tank Construction Standards

DOT - US Department of Transportation (the most common)

AAR - American Association of Railroads

CTC - Canadian Transport Commission

ICC - Interstate Commerce Commission (U.S.)

Element 2 - Class Designation (see Parts 2, 3, 4)

105 - Pressure Tank Car, liquified compressed gases of all types

112 - Pressure Tank Car, liquified compressed gases of all types, except Chlorine; some cars carry only Anhydrous Ammonia.

114 - Pressure Tank Car, liquified compressed gases, except Chlorine

111, 103 - Non-Pressure Tank Cars, used for most other types of DCs and non-DCs, 111 cars can accept light pressurization.

Element 3 - Safety Equipment
(see Part 5)

A - no significance, separates elements 2 and 4 (note: all tank cars carrying compressed gases must be equipped with double-shelf couplers

S - equipped with head shields and double-shelf couplers.

J - equipped with jacketed thermal insulation, head shields, and double-shelf couplers.

T - equipped with sprayed-on thermal protection, head shield, and double-shelf couplers.

Element 4 - Tank Test Pressure In Pounds per Square Inch
(psi)

Test pressure does not indicate the pressure at which the tank will yield. Table 1 below, shows the relationship between safety valve release pressure, test pressure, and bursting pressure for a selected range of tank types.

TABLE 1

PRESSURE CHARACTERISTICS OF SELECTED PRESSURE TANK CARS

Car Type	Tank Test Pressure (psi)	Tank Bursting Pressure (psi)	Safety Valve Release Pressure (psi)
105 - 100	100	500	75
105 - 300	300	750	225
105 - 500	500	1 250	375
105 - 600	600	1 500	450
112 - 200*	200	500	150
112 - 400	400	1 000	300
112 - 500	500	1 250	375
111A 100 W4	100	500	75

* 114 cars are similar to 112.

Source: RTC Red Book, 387, 397.

Normal operating pressures are well below the safety valve release pressure. The safety valve release pressure is usually 75% of the test pressure, though the regulatory maximum is 82.5%. Operating pressure also varies according to the density of the material loaded, the amount loaded, and the outside temperature surrounding the tank.

Test pressure is set by filling the tank with water and pressurizing it to the test limit, where it must remain for at least 10 minutes without signs of distress. Every tank car produced must successfully complete this test. All tanks and safety valves undergo periodic retesting.

Bursting pressure is the theoretical upper limit of tank endurance. In reality, flame contact or impact damage will weaken the tank, leading to a somewhat lower bursting pressure.

Element 5 - Tank Material

'no letter' - carbon steel

AL - aluminum alloy

N - nickel or nickel/steel alloy

C, D or E - stainless steel, alloy steel.

Element 6 - Type of Welding

W - fusion welding (almost exclusively used)

F - forge welding

Element 7 - Commodity Markings

Tank cars used exclusively to transport one commodity are marked with a letter to indicate the commodity type.

PART 2 - DOT 105 TANK CARS

These cars are used to transport the most dangerous liquids and corrosive and poisonous gases. Some examples are as follows.

Compressed Gases

- Flammable Gases
  - o Ethylene Oxide

- Corrosive or Toxic Gases
  (this is the most frequent use of 105 cars)

  - o chlorine
  - o anhydrous ammonia
  - o sulphur dioxide

- Liquids

  - o tetraethyl lead

- Solids

  - o Sodium (metallic) - only if the car is equipped with heater coils to liquify the sodium for loading and unloading; at other times, it is allowed to solidify.

Depending on their test pressures, 105 cars are subject to differing safety requirements. RTC regulations specify that all 105 tank cars with test pressures below 500 psi must have head shields, double-shelf couplers and thermal insulation equivalent to that required for DOT 112/114 cars (see Part 3).

Those 105 tank cars with test pressures of 500 psi or more are required only to have double-shelf couplers and thermal protection. Head shields are omitted in this case because the thickness of tank head metal needed to contain such pressures is roughly equivalent to the additional thickness provided by a head shield.

The metal used to form the 105 tank cars varies, at its minimum, from five-eights of an inch in cars with test pressures up to 300 psi, and eleven-sixteenth of an inch in those above this pressure. This is only the minimum thickness; maximum thickness is somewhat higher in sensitive areas.

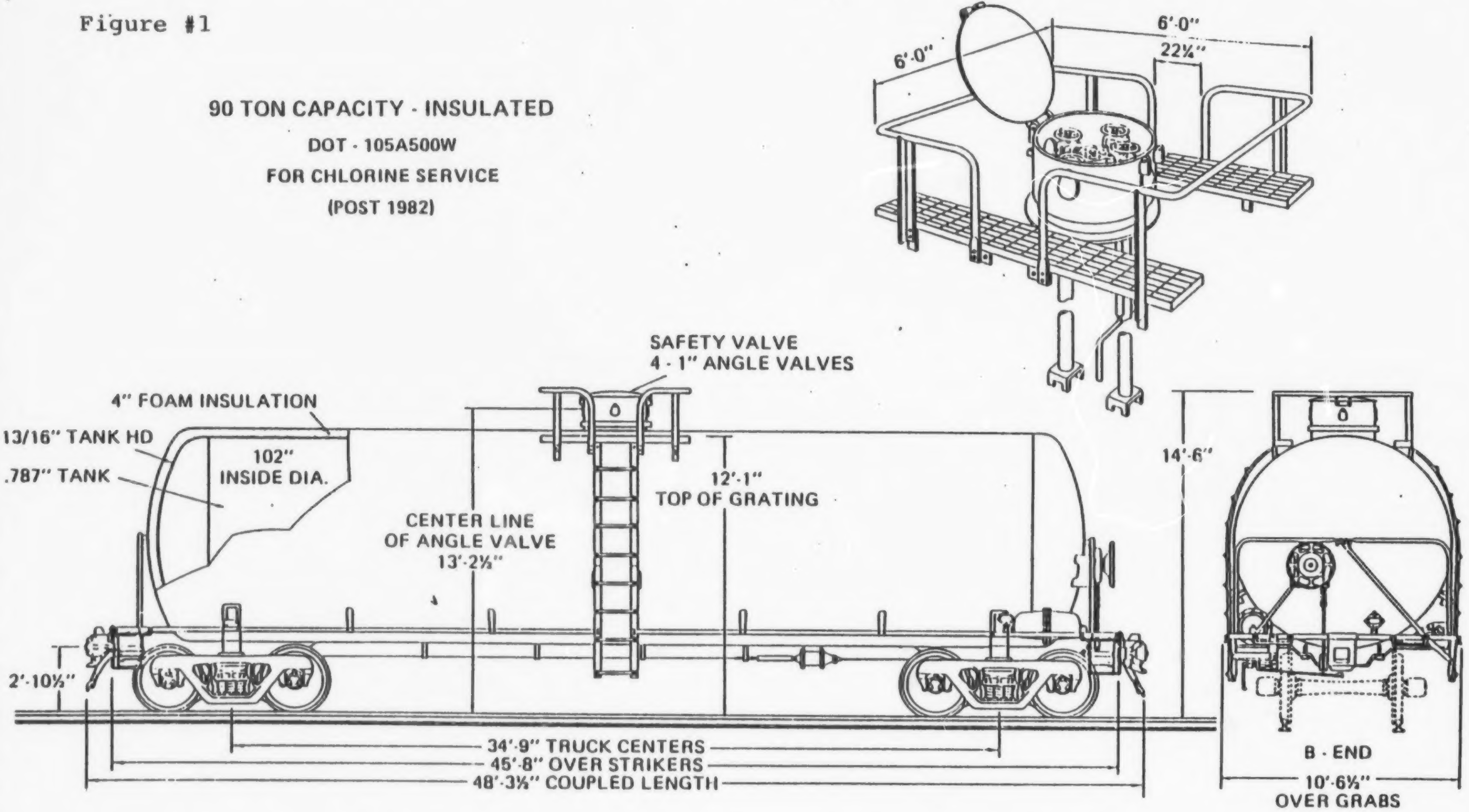
The capacity of 105 cars varies somewhat, since cars may be built to specific requirements for certain commodities but, on the whole, it is around 90 tons capacity. Mass is used as a criterion rather than volume because compressed gases are the common shipment.

Loading and unloading of 105 cars can be done only through valves on the upper surface, which are surrounded by a protective dome. Both bottom fittings and washouts for cleaning the tank are forbidden for safety reasons.

Safety release is permitted to be only by self-resealing safety valves. Typically, the valve opens at 75 % of the test pressure.

Figure 1 shows the dimensions and features of modern 105 tank cars. It should be noted that the illustration shows a car whose test pressure is above that where head shields are required.

Figure #1



90 TON CAPACITY - INSULATED

DOT - 105A500W

FOR CHLORINE SERVICE

(POST 1982)

6'-0"
6'-0"
22¼"
SAFETY VALVE
4 - 1" ANGLE VALVES
4" FOAM INSULATION
13/16" TANK HD
.787" TANK
102"
INSIDE DIA.
CENTER LINE
OF ANGLE VALVE
13'-2½"
12'-1"
TOP OF GRATING
14'-6"
2'-10½"
34'-9" TRUCK CENTERS
45'-8" OVER STRIKERS
48'-3½" COUPLED LENGTH
B - END
10'-6½"
OVER GRABS

CAPACITY & WEIGHTS

NOMINAL CAPACITY @ 125% FILLING DENSITY - 90 TONS
ESTIMATED LIGHT WEIGHT - 79,700 LBS.
RAIL LOAD LIMIT (100 TON TRUCKS) - (5'-10" WHEEL BASE) - 263,000 LBS.

Source: GATX Tank Car Manual,
courtesy, CP Rail.

PART 3 - DOT 112 AND 114 TANK CARS

These tank cars are commonly used to transport flammable compressed gases and anhydrous ammonia. They may also be used to ship all other poisonous and corrosive compressed gases with the exception of Chlorine. Liquified petroleum gases (LPG) commonly transported are propane and butane. Other common flammable compressed gases are butadiene and propylene.

In shape and design, 112 and 114 cars are very similar. Both are loaded and unloaded from valves in a protected upper dome. Safety release valves are also located in this dome. Some 114 cars can be distinguished by washouts on the bottom surface of the tank to permit it to be washed out after use. This type of 114 car is rare; even more so are 114 cars with bottom fittings for unloading, though this is a permissible feature in certain classes of 114 cars.

RTC regulations require all 112 and 114 cars be equipped with double-shelf couplers, head shields, and jacketed thermal insulation. This insulation is required to resist torch fires for at least 30 minutes and pool fires for at least 100 minutes. Fire endurance is the sole criterion; thickness of insulation is not specified. Generally, the layer of insulation is around 4 inches thick.

The thermal insulation in 'J' cars is protected by a one-eighth inch thick steel jacket. In 'T' cars, this jacket is foregone in favor of a sprayed on thermal coating which resists fire.

Safety release is allowed only through self-resealing safety valves. As seen in Table 1 above, safety release pressure is between 75% and 82.5% of the tank test pressure.

The volume capacity of 112 and 114 cars varies according to the density of the gas with which it is loaded. In Canada, a nominal capacity of 26 500 Imperial gallons is common. The typical test pressures are between 340 and 500 psi.

Figure 2 shows a typical 112 tank car. The half-inch thick head shield in this case forms part of the jacket surrounding the insulation.

PART 4 - DOT 103 AND 111 TANK CARS

These tank cars are, on the whole, used to transport liquids of various types. Most strongly flammable liquids and corrosives are carried in 111 cars. Other liquids, including non-DCs as well as DCs, are shipped in 103 cars.

A distinctive feature of most 103/111 cars is the lack of a protective dome for top fittings (see Figure 3). Unloading is almost exclusively done through bottom outlet valves, which in older cars are operated from a 'stuffing box' on the upper surface.

Sulfuric acid is usually transported in standard 111 cars, and is unloaded from bottom outlet valves. A number of 111 cars have been modified specifically for this commodity and, as seen in Figure #4, are unloaded from fittings on the upper surface of the tank.

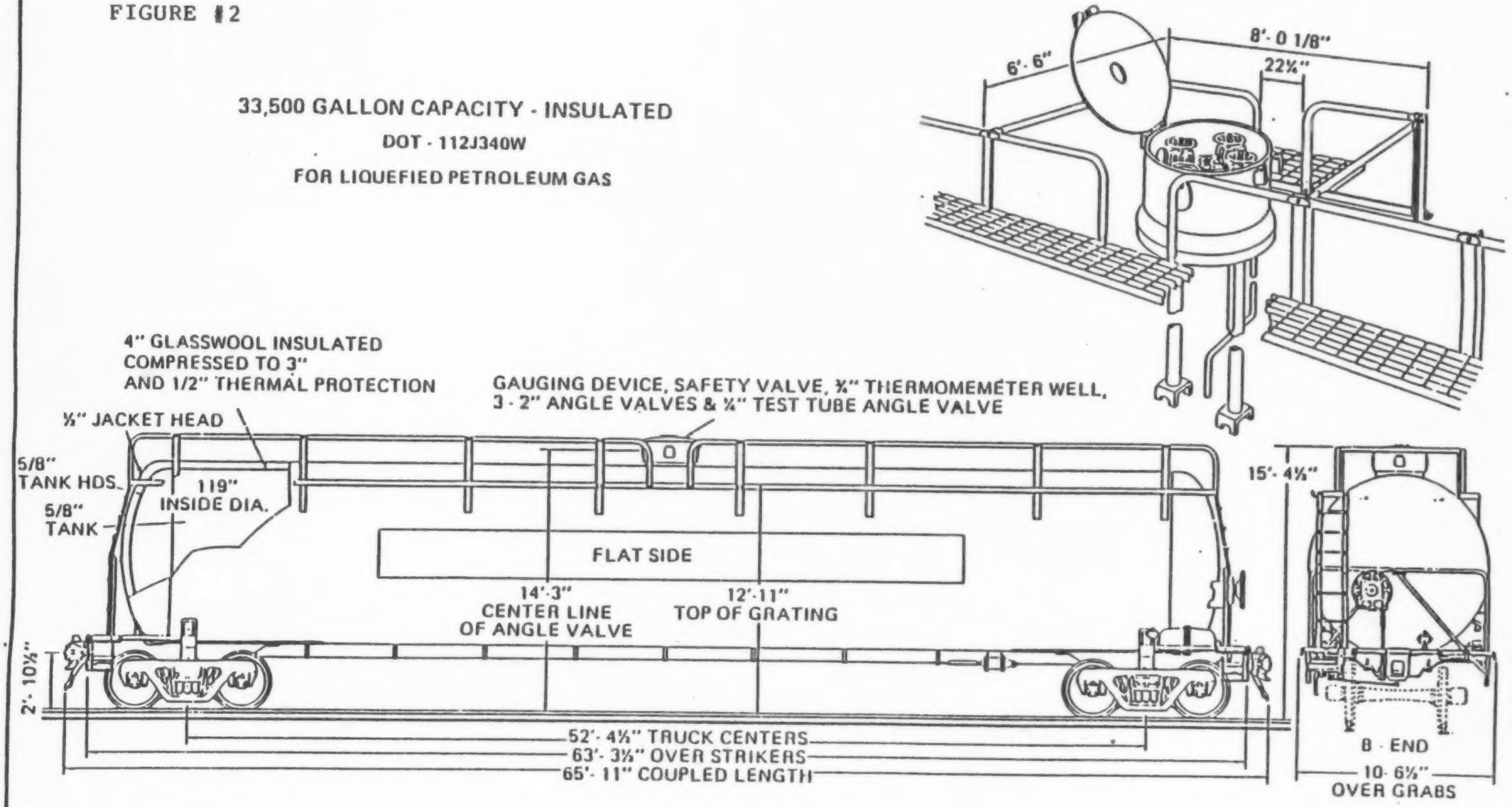
A distinctly visible difference between 103 and 111 cars is that 103 cars sometimes have a dome-like protuberance on the upper surface. This is an °expansion dome' designed to allow for expansion of the shipment as temperatures change. In 111 cars, possible expansion is allowed for within the body of the tank.

FIGURE #2

33,500 GALLON CAPACITY - INSULATED

DOT - 112J340W

FOR LIQUEFIED PETROLEUM GAS


8'- 0 1/8"
22¼"
6'- 6"
4" GLASSWOOL INSULATED
COMPRESSED TO 3"
AND 1/2" THERMAL PROTECTION
GAUGING DEVICE, SAFETY VALVE, ¾" THERMOMEMETER WELL,
3 - 2" ANGLE VALVES & ¼" TEST TUBE ANGLE VALVE
½" JACKET HEAD
5/8" TANK HDS.
119" INSIDE DIA.
5/8" TANK
FLAT SIDE
14'-3" CENTER LINE OF ANGLE VALVE
12'-11" TOP OF GRATING
2'- 10½"
52'- 4½" TRUCK CENTERS
63'- 3½" OVER STRIKERS
65'- 11" COUPLED LENGTH
15'- 4½"
B - END
10- 6½" OVER GRABS

CAPACITY & WEIGHTS

NOMINAL CAPACITY @ 58.28% FILLING DENSITY - 33,500 GALS;
ESTIMATED LIGHT WEIGHT - 99,500 LBS.
RAIL LOAD LIMIT (100 TON TRUCKS) - (5'- 10" WHEEL BASE) - 263,000 LBS.

Source: GATX Tank Car Manual,
courtesy CP Rail.

FIGURE #3

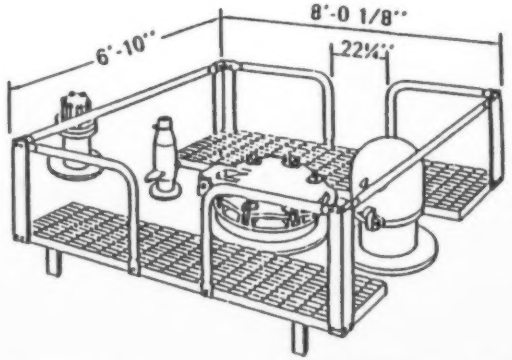
20,000 GALLON CAPACITY - NON INSULATED

DOT - 111A100W1

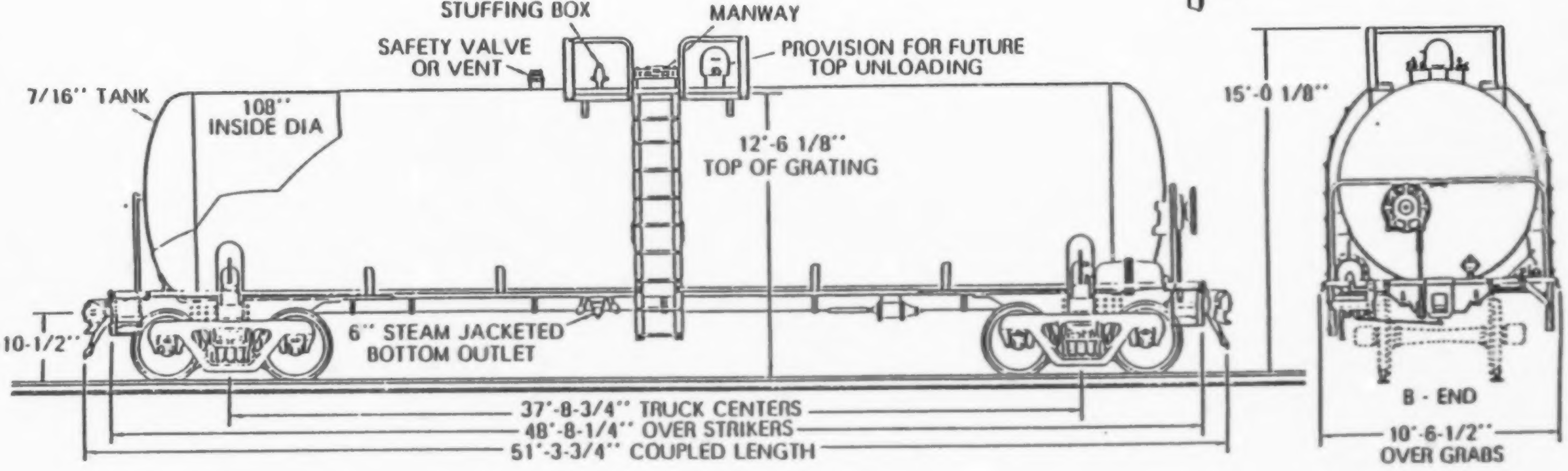
FOR GENERAL SERVICE COMMODITIES

4'' SLOPE TO STRAIGHT CENTER SECTION.

(PRE 1983)



6'-10''
8'-0 1/8''
22¼''



STUFFING BOX
MANWAY
SAFETY VALVE OR VENT
PROVISION FOR FUTURE TOP UNLOADING
7/16'' TANK
108'' INSIDE DIA
12'-6 1/8'' TOP OF GRATING
15'-0 1/8''
2'-10-1/2''
6'' STEAM JACKETED BOTTOM OUTLET
37'-8-3/4'' TRUCK CENTERS
48'-8-1/4'' OVER STRIKERS
51'-3-3/4'' COUPLED LENGTH
B - END
10'-6-1/2'' OVER GRABS

CAPACITY & WEIGHTS

NOMINAL CAPACITY @ 2% OUTAGE - 20,000 GALS.
ESTIMATED LT. WT. (NON COILED) - 57,800 LBS.
RAIL LOAD LIMIT (100 TON TRUCKS) -263,000 LBS.

Source: GATX Tank Car Manual,
courtesy CP Rail.

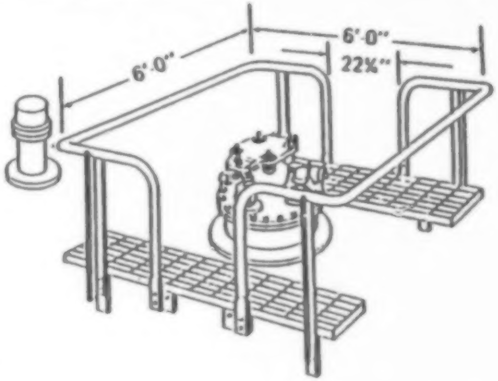
COMMODITY MAXIMUM DENSITIES

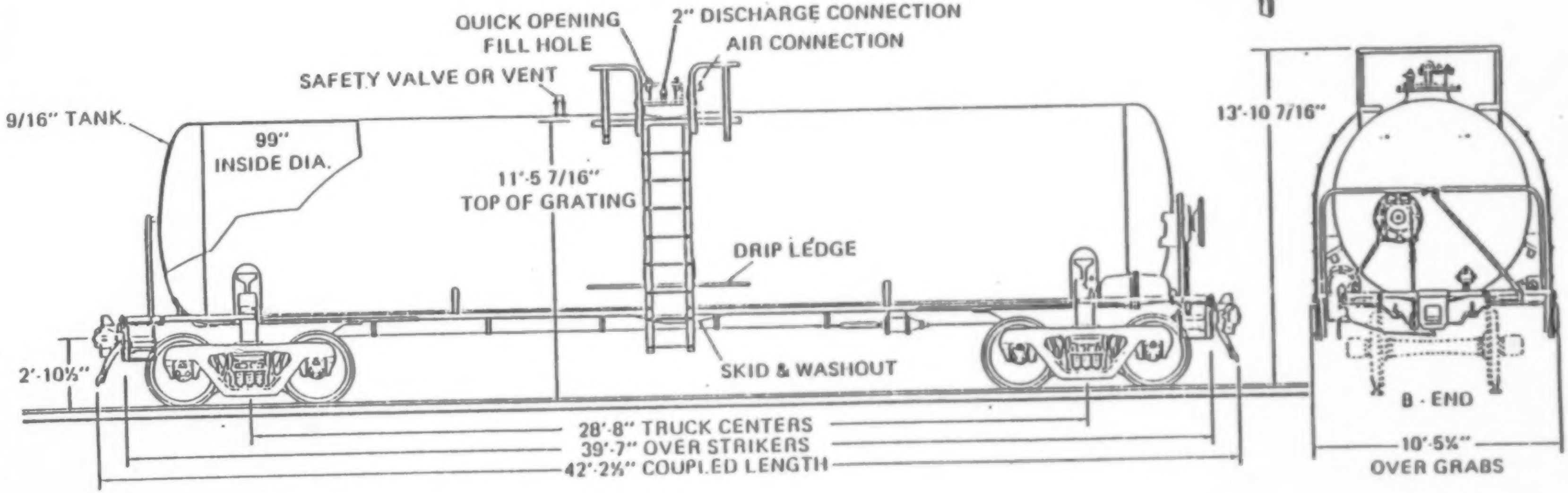
TRUCK CAPY.	WHEEL BASE	NO. OF COILS	COMM. WT./GAL.	NON - COILED COMM. WT./GAL.
70 TON	5'-8''	16	8.02#	8.13#
100 TON	5'-10''	16	9.94#	10.04#

FIGURE #4

13,600 GALLON CAPACITY - NON INSULATED

DOT - 111A100W2
FOR SULFURIC ACID SERVICE
(POST 1982)




QUICK OPENING FILL HOLE
2" DISCHARGE CONNECTION
AIR CONNECTION
SAFETY VALVE OR VENT
9/16" TANK
99" INSIDE DIA.
11'-5 7/16" TOP OF GRATING
DRIP LEDGE
SKID & WASHOUT
2'-10½"
28'-8" TRUCK CENTERS
39'-7" OVER STRIKERS
42'-2½" COUPLED LENGTH
13'-10 7/16"
B - END
10'-5¾" OVER GRABS

CAPACITY & WEIGHTS

NOMINAL CAPACITY @ 2% OUTAGE - 13,600 GALS.
ESTIMATED LT. WT. (NON COILED) - 55,200 LBS.
RAIL LOAD LIMIT (100 TON TRUCKS) - 263,000 LBS.

COMMODITY MAXIMUM DENSITY

TRUCK CAPY.	WHEEL BASE	NON - COILED COMM. WT./GAL..
100 TON	5'-10"	15.2#

Source: GATX Tank Car Manual,
courtesy CP Rail.

RTC regulations demand that all 103/111 cars used to transport DC's be equipped with double-shelf couplers. At present , tank car owners are carrying out some retrofitting of 103/111 cars with skids to protect bottom fittings from shearing off in accidents, in accordance with RTC requirements.

The capacity of 103/111 cars is around 16 600 Imperial gallons, depending on the characteristics of the tank. Those 111 cars modified for sulfuric acid shipment are smaller, only 11 300 Imperial gallons in capacity, due to the weight of this commodity.

Safety release can be provided either by a self-resealing safety valve or by a safety vent, known as a 'frangible disc'. This is a pressure sensitive disc which, once broken, cannot reseal. Safety vents are permissible only for non-flammable shipments.

Tank metal, as seen in Figures 3 and 4 is between seven-sixteenths of an inch for normal 111 cars, and nine-sixteenths in sulfuric acid 111 cars.

PART 5 - SAFETY MEASURES: TANK CAR RETROFITS

A - Double-shelf couplers
B - Head shields
C - Thermal insulation
D - Roller bearings.

A. Double-shelf Couplers

Double-shelf couplers have been a very successful safety modification to railway equipment. Figures 5 and 6 show the 'E' type top-and-bottom shelf coupler.

Comparing this coupler to the conventional model shown in Figure 7 makes very clear what is meant by the 'double-shelf.' These two shelves are very robust, and can absorb a great amount of force.

Double-shelf couplers serve two basic functions. First, they prevent the couplers of other cars, whether a proper connection has been made or not, from overriding the double-shelf coupler and striking the tank head.

Second, they add longitudinal stability to the cars to which they are connected. This tends to keep derailed cars in line and reduces the force involved when derailed cars begin the jack-knife.

Override prevention is a key function in slow-speed yard accidents. The upper shelf restrains conventional couplers from slipping upwards. In fact, the upper shelf can 'catch' and somewhat restrain overrides in cars that have not properly connected with the tank car.

In accidents where speed or compression forces are more extreme, the tendency of double-shelf couplers is to 'lock in' other couplers and restrain upward motion. When upward force is too strong, it has been noted that double-shelf couplers tend to rip the coupler loose from the other car. As a result, the overriding car makes head-to-head contact with the tank, spreading the force over a much larger surface than would be the case if the coupler struck the tank.1 Head shields further reduce the effect of such impacts.

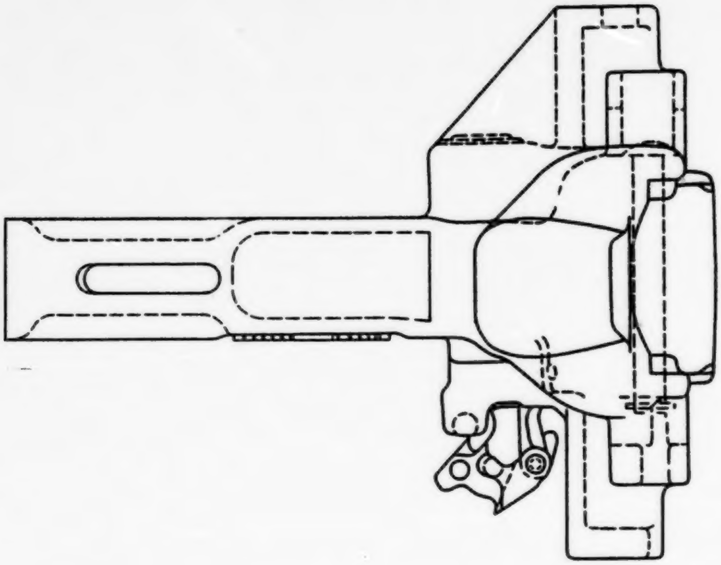


Figure 5

A side view of the Standard 'E' top and bottom shelf coupler.

Source: CP Rail.

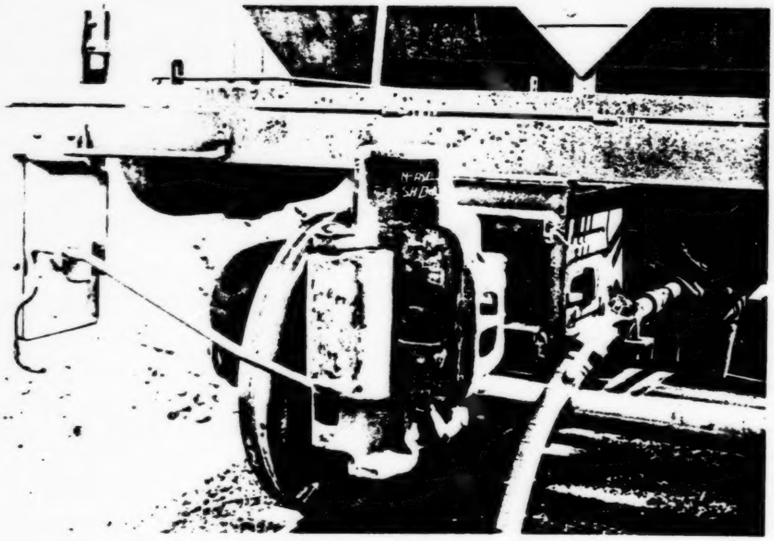


Figure 6

The double-shelf coupler in service.

Standard equipment on all tank cars, the heavy steel flanges, or 'shelves' placed above and below the body of the coupler itself act to prevent overrides and keep derailed cars in line.

Source: B. Sasaki.

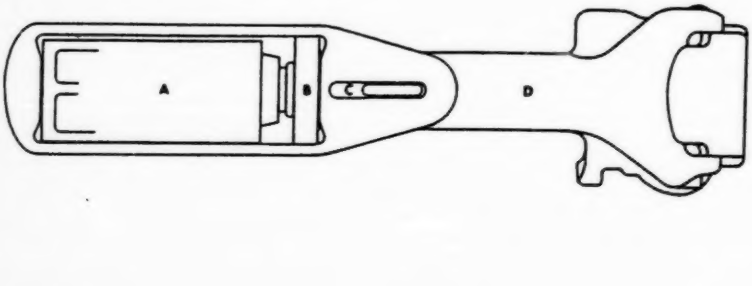


Figure 7

The standard 'E' type coupler (side view).

Note the differences between this coupler and the double-shelf coupler, above.

Source: CP Rail.

In the derailment at Livingston, Louisiana, where 'extraordinary dynamic forces were present,' shelf couplers prevented head punctures by keeping derailed cars reasonably in-line during the critical first few moments.[2] Most damage was later done during jack-knifing. In accidents where circumstances are less extreme, shelf couplers reduce shell punctures by delaying jack-knifing until some energy kinetic has been dissipated.

The NTSB has stated that 'the conversion to shelf-couplers on tank cars has proven to be unquestionably cost-effective.'[3] Nonetheless, experiments and accident experience have shown that shelf-couplers are most valuable when acting in concert with other safety equipment in general, and head shields in particular.

B. Head Shields

A rash of severe LPG and toxic gas releases due to head punctures led, during the 1970s, to the installation of head shields on many tank car types.

The head shield is essentially an extra thickness of metal used to deter penetration of the tank head. The form of this shield has gone through several changes. At first, it was a plate mounted on the end of the car. Later, the shield was incorporated in the insulation jacket surrounding the tank head but covered only the lower half of the tank head. RTC regulations now call for head shields on all 105, 109, 112 and 114 tank cars. This shield is part of the jacket surrounding the thermal insulation, covers the entire head of the tank, and is at least half an inch in thickness.[4] The sole exception, as noted in Part 2 above, are 105 tank cars with test pressures above 500 psi, whose tank heads alone are thick enough to serve as head shields.

The head shield prevents punctures by absorbing and distributing the force of objects colliding with it. Penetration of the shield is rare, but the impinging object generally lacks, after tearing the shield, enough power to seriously damage the tank head. Modern shields cover the entire tank head, and their curvature has been noted to deflect impacts as well.

Experience shows that, even in extreme accidents, head shields greatly reduce the incidence of head punctures. The head shield is often severely scored and dented, but the tank head is seldom disturbed.

The head shield is really best thought of as the inseparable companion of the double-shelf coupler and, as shown earlier, this combination has in the last six years been responsible for a 94% drop in head punctures of 105 and 112/114 tank cars.[5]

C. Thermal Insulation

A series of fire-induced BLEVEs during the 1970s spurred the insulation of tank cars carrying flammable gases. Direct flame impingement on cars containing such highly pressurized contents was a recipe for disaster.

Thermal insulation has never been intended to completely prevent these incidents. Instead, it is intended to allow emergency responders enough time to evacuate nearby areas and, if they feel conditions warrant the risk, to attempt to cool the tank with large volumes of water.

AAR standards, accepted in Canada, call for thermal insulation to delay rupture for at least 30 minutes when in contact with a torch fire, and for 100 minutes in a pool fire. Previously, uninsulated tank cars had been known to burst, depending on the specific circumstances, in approximately 10 minutes. 6

The insulation now provided consists of various heat-resistant materials as shown in Figure 8. Most 105, 112 and 114 tank cars are of this 'J' type. It is also permissible to use a sprayed-on coating which forms a fire-resistant covering on the tank surface. (see Part 1)

DOT 105 tank cars, because they may contain flammable, poisonous, and corrosive compressed gases, are subject to the same insulation requirements.

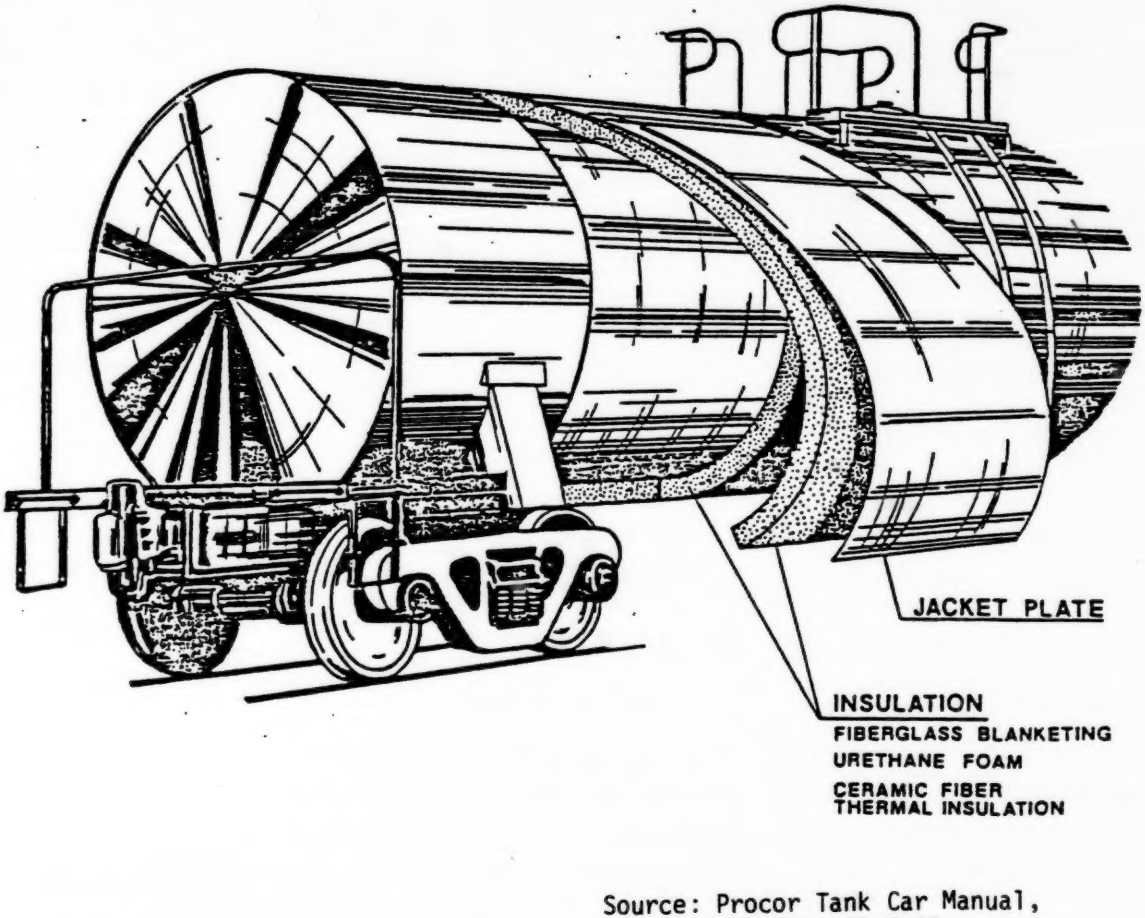
Accident experience shows thermal insulation to be very successful. It has caused a 93% reduction in the occurrence of fire-induced ruptures.[7] Where ruptures have occurred, they have been delayed for several hours, or even days. Since safety valves are usually open throughout the period of direct flame contact, very little of the tank's original contents remain when rupture does occur. This drastically reduces the damage done by the explosion.

The lone dark spot in this situation is the possibility of damage to the insulation jacket. This occurred in Mississauga, where BLEVEs occurred within 18 and 28 minutes of being involved in flame. No data is available to adequately predict the likelihood of having this sort of damage recur, nor does the accident record show any subsequent occurrences. It is hoped that widespread installation of double-shelf couplers and head shields may help to reduce the extreme dynamic conditions which caused such jacket damage.

The jacket type of insulation has been shown to play a role in reducing shell punctures. The one-eighth inch steel jacket and the enclosed insulation act, in addition to their designed function, to deflect and cushion side strikes.

FIGURE #8

THERMAL INSULATION FOR 'J' TYPE TANK CARS


JACKET PLATE
INSULATION
FIBERGLASS BLANKETING
URETHANE FOAM
CERAMIC FIBER THERMAL INSULATION

Source: Procor Tank Car Manual,
Courtesy CP Rail.

This has been shown, coupled with the longitudinal, stability imposed on car strings by double-shelf couplers, to have brought about a 67% decrease in side punctures.8

D. Roller Bearing

There are two common types of bearings for the axle ends or 'journals,' of rail cars--plain, and roller. It is the bearings which enable the wheels to roll with a minimum of friction, and therefore they are critical elements in rail safety.

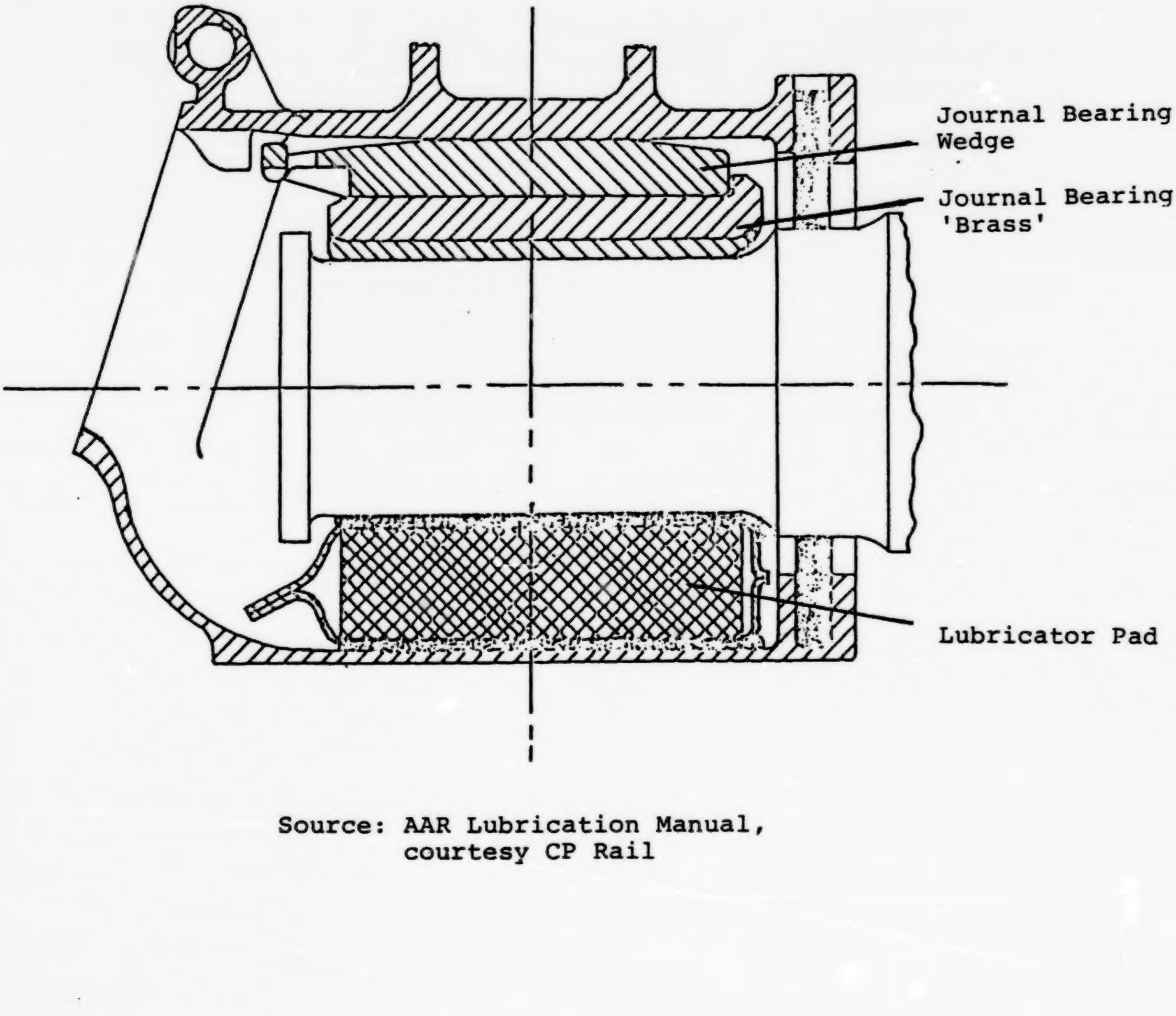
Plain bearings have been in use throughout most of the history of rail transportation, and are simple in design. The journal assembly is diagrammed in Figure 9. The axle end, because the weight of the car presses down, in essence, through the axle, 'bends' upward at each end. This weight is borne by the 'journal wedge', and is communicated to it by the 'journal bearing'. This journal bearing is in direct contact with the axle. This journal bearing is called a 'brass', though it is in fact composed of white metal.

The friction generated in this assembly is reduced by keeping the components well lubricated. The bottom surface of the axle is in contact with a thick cotton pad called the lubricator. This pad is saturated in oil and rests in an oil bath. The entire assembly is surrounded by the 'journal box'. This type of bearing requires periodic maintenance to replace worn lubricators and to ensure that the oil bath is sufficiently full.

Should the lubricator and the journal cease to be in contact or lint from a torn pad get caught in the collar, overheating of the unlubricated sections of the journal occurs. This can become progressive, leading to combustion of the lubricators, melting of the journal bearing, and eventually thinning and shearing off of the journal.

Figure #9

PLAIN JOURNAL ASSEMBLY


Journal Bearing Wedge
Journal Bearing 'Brass'
Lubricator Pad

Source: AAR Lubrication Manual, courtesy CP Rail

Roller bearings were first installed in the 1950s and have become a major item for retrofits in all rolling stock. Approximately 65% of revenues cars in the fleets of Canadian railways now have these bearings. This bearing is a sealed unit, comprised of a journal surrounded by a number of cylindrical 'roller' bearings immersed in lubricating grease These bearings experience far fewer burn-offs than do plain bearings.

Statistics show that, depending on the degree of plain bearing maintenance, roller bearings experience between 6.5 and 1.7 times fewer journal burn-offs. Even scrupulous plain bearing maintenance appears to be unable to bring their endurance to better than about 60% of that found in roller bearings.[9]

One balancing factor which has been pointed out in some sources is that the onset of burn-offs in roller bearings appears to be more rapid than in plain bearings. Even at high speeds, plain bearings could take up to 30 minutes to burn-off. It is suspected, however, that roller bearings may burn-off very soon after the onset of failure. This makes detection somewhat more challenging.[10]

E - TRACKSIDE DETECTION SITES

The trackside detection sites now installed in Canada consist of two monitors which the RTC requires, and one which is voluntarily installed by the railways. These monitors are designed to detect the symptoms of equipment failures which, if not arrested, could lead to damage to rolling stock or track or, in the worst case, a derailment.

The Hot - Box Detector

Hot-box detectors are infrared sensors which read the outside temperatures of journal boxes as they pass directly overhead. These monitors are installed just outside the gage of the rails. Excessive friction in the journal assemblies generates such great heat that the surrounding boxes will be clearly distinguishable from ones operating normally.

The Dragging Equipment Detector

The mechanism which absorbs the compression and extension forces in trains has been known to disconnect. Such broken 'draft gear' can catch on ties and other track features, and has caused several accidents. Dragging chains and other types of equipment must also be protected against.

The dragging equipment detector is a spring-loaded panel approximately one foot high, running laterally between the rails and extending outward approximately one foot to either side of the gage. When struck by a piece of dragging equipment, the panel is knocked down and an alarm is set off.

The Hot Wheel Detector

A hot-wheel detector is an infrared sensor standing to one side of the gage, positioned in such a way as to be able to read the temperature of a portion of the 'tread' of each wheel.

Wheels which are cracked of flattened can become overheated, causing vibration or fracturing. Damaged wheels can cause derailments. The infrared sensor checks for heat as a symptom of such flaws.

RTC regulations do not require trackside detection sites be equipped with hot-wheel detectors. These installations are entirely at the initiative of the railways, in keeping with their goal of maximizing operating safety. These devices are not yet installed on all trackside detection sites across the country, but are found in all major urban centers.

Information Display

Though both CN and CP collect essentially the same information from these trackside detection sites, the information is handled differently. In both cases, readings from the various monitors are processed in computer huts at trackside.

CP has chosen to display the information, when processed, on light boards at trackside. CN, on the other hand, relays the information to the central dispatcher, who then communicates it to the train crew.

The presentation of these results enables railway personnel to tell on which side of the train the defect occurred, and to measure in axles its distance from the head of the train. 11

[1] Department of Commerce, 1980, p. 68 (5.5).

[2] NTSB, 19833A, p. 49 (5.17).

[3] Ibid.

[4] RTC, 'Red Book' 1986, p. 387 and 397 (2.9)

[5] AAR, 1985, p. 15 (5.2)

[6] Interview with Chief R. Gaade, City of Toronto Fire Department, September 22, 1986.

[7] AAR, 1985, p. 15 (5.2)

[8] Ibid.

[9] Show - Cause Hearing, 1981, p. 26 (2.1)

[10] Ibid., p. 40 (2.1)

[11] NTSB, 1983A, p. 49 (5.17).

APPENDIX C

Probabilities: Process and Assumptions

APPENDIX C

PROBABILITIES: PROCESS AND ASSUMPTIONS

The probabilities displayed in Tables 2-9 and 2-12 were never intended to have the rigor of formal risk analysis. Their purpose was to provide a reasonable estimate of the likelihood of rail DC accidents in the Toronto area and their relationship in terms of orders of magnitude.

It should be noted that these two tables cannot be compared, due to different methods of generation and data parameters.

Table 2-9

This table attempts to relate the rate of train derailments and collisions nationally to the rail network within the City of Toronto. This data comes from the RTC's 'Examination of Canadian Railway Derailments and Collisions Jan. 1 1984 to March 21, 1986'. Data on train traffic and DC volumes was provided by each railway. CN DC volumes are from 1982, and were extracted from the Burton-Post Report. The propane incident factors were taken from an article by Raj and Glickman, listed as item 4.13 in the Bibliography (App. E).

In order to account for the weaknesses and potential for variation encountered in the data, this table includes two ranges. The lower range represents a situation in which train traffic has markedly increased (35%). This is a high assumption, and is intended to provide a 'worst case' boundary.

The upper boundary is calculated from the most accurate available rail data for 1985. This is the situation as it presently exists, to the degree the methodology employed can manage it.

It was not felt to be necessary to create a range postulating a decrease in train traffic. Suffice to say that occurrences which are already improbable would become more so. The most important aspect of sensitivity was felt to be an increase in rail traffic.

ASSUMPTIONS:

1. That the national rate of train derailments and collisions on main tracks is representative of the situation on tracks within the City of Toronto.

2. That the national rate of major DC releases in main track derailments and collisions is representative of the situationon tracks in the City of Toronto.

3. That the figures for the volumes of DC's transported in the Toronto CMA in 1982 by CN is representative of the situation in 1985 on tracks within the City of Toronto.

4. That the figures for the volumes of DC's transported in the Toronto CMA in 1985 by CP are representative of the situation on tracks within the City of Toronto.

5. That the likelihood that a DC will be involved in a major release is directly related to the proportion it constitutes of total DC traffic.

6. That it is possible for the volume of train-miles in the City of Toronto rail system to increase by 35%.

7. That volumes on individual types of DC's can double, while the volumes of others (those which are specified below) remains the same.

PROCESS: (for both range boundaries)

1. Find the number of through and transfer trains running on each CN and CP subdivision within the City of Toronto.

2. Multiply this figure by the number of miles of each subdivision which lies within the City of Toronto. This produces a train-mile figure.

Note: in all further calculations, the statistic in question was calculated for CN and CP individually and then summed to give a total figure, since both railways can be treated as independent entities.

3. Multiply train-miles by the rate of train derailments and collisions per million train miles.

4. Multiply train-miles by the rate of major DC release in train derailments and collisions. Check against the proportion major DC releases constitute of all train derailments and collisions.

5. Find proportion of DC traffic constituted by;

   Flammable Compressed Gases
   Poisonous and Corrosive Compressed Gases
   Flammable Liquids
   Corrosives
   All Other DC's not elsewhere specified

   To calculate the lower range boundary for releases of these, double the proportion it constitutes of total DC traffic, taking the additional volume out of the 'All Other DC' category to stay within 100% of all DC's.

6. Taking the probability figures for releases of Flammable Compressed Gases, multiply into it the proportion of LPG accident types calculated by Raj and Glickman.

This methodology clearly has weaknesses. There can be no certainty that national accident rates are comparable to those in the City of Toronto; in fact, all evidence points to the network in the City being substantially safer.

Second, the figures provided on DC commodity volumes leave between 20% and 40% of the total volume unidentified. It is likely that some of these substances might fit into the four classes chosen. This fuzziness does enable one, however, to assume doubling of the volume of certain commodity types without having to alter the proportions of other types.

Third, there is no certainty that the involvement of a commodity class in a major DC release will be proportional to its frequency of transport. This is the only logical assumption which could be made in the circumstances, but randomness may have a strong influence in reality.

Fourth, the proportions taken from Raj and Glickman are not well documented in the article itself. Therefore, there may be some problems in these figures which are not readily apparent to the reader.

Finally, the volume of train traffic and the distribution of volumes of DC types transported are subject to fluctuation. Unforeseen changes in industrial location and activity can greatly influence the amount and type of train and DC traffic. Though the assumption made of a 35% increase in train miles is intentionally high, smaller increases are not inconceivable. The recent trend, however, has been towards a decline in both train miles and DC traffic within the City of Toronto.

Table 2-12

This table is modelled on the approach taken by CP in its Submission to the Federal Task Force of May 1986. This method corrects some of the weaknesses of the earlier probability table. It allows variations in the technical quality of rail plant to be accounted for. Unfortunately, only main track over-the-road train derailments are considered, on the ground that only they generate the dynamic conditions likely to cause a major DC release. Collisions are unaccounted for.

Data on train traffic was taken from submissions made by both CN and CP to the Federal Task Force, as was data on the volume of DC traffic on each subdivision. As such, the volume of DC traffic was undifferentiated by commodity classes.

ASSUMPTIONS:

1. That the rate of occurrence nationally of over-the -road train derailments on specific types of track and by specific causes is representative of the situation on particular subdivisions in the City of Toronto.

2. That CN cars counts can be considered as comparable to CP car movements.

3. That the incidence of over-the-road train derailments is the same for CN as it is for CP.

4. That CN six-month DC volumes can be doubled to give yearly totals.

5. That only through and transfer trains will be counted in the calculation of train miles; switching and reversing movements will be excluded.

6. That the train derailment rate calculated on the basis of approximately 50 million train miles on CP in 1984 - 85 will be readily applicable to CN as well.

7. That all journal failure accidents can be excluded because of the hot-box detector protection provided in the Toronto area.

PROCESS:

1. Find the number of train miles on each subdivision in the City of Toronto, for both CN and CP.

Note: in all future calculations, the figures for CN and CP will be calculated individually, then summed to provide a total figure, since they are independent entities.

2. Select from the list of 103 over-the road train derailments in 1984 - 85, the;

   83 accidents including jointed rail failures, but excluding journal failures and topographic causes.

   66 accidents applicable to Continuous Welded Rail subdivisions, excluding journal failures, jointed rail failures, and topographic causes.

   Relate this figure to the number of train miles on the CP system, to give overall accident rates of;
   83 accidents = 1.57 per million train miles
   66 accidents = 1.32 per million train miles

3. Calculate the rate of train derailments for each CN and CP subdivision, based on track type, then sum for total figure.

4. Calculate expected DC involvement (not necessarily, but possibly releasing DC's) rate, uncorrected for volume, for each subdivision, noting that .12 of accidents on jointed rail involved DC's nationally, as opposed to .106 of accidents on continuous welded rail.

5. Calculate the rate of DC involvement (not necessarily, but possibly releasing DC's), corrected for subdivision DC volumes, in train derailments. This is based on the relationship between the percentage volume of DC's transported on each subdivision, divided by the average percentage of DC's transported on the CN and CP systems as a whole. Sum to give the total figure.

APPENDIX D

A Guide To Hazard Assessment

APPENDIX D

A GUIDE TO HAZARD ASSESSMENT

The Hazard Assessment procedure is intended to be a subjective appraisal, offering Advisory Committee members an opportunity to apply their professional expertise to this subject. Emphasis is placed on analyzing those characteristics which make particular geographic areas more or less vulnerable to the effects of DC accidents.

Each railway Subdivision has been divided into a nember of subsections according to criteria such as topography, road crossings, major rail facilities, and other factors. These subsections represent the basic geographic area to be scrutinized by the Study.

According to the decisions of the Advisory Committee at its June 9th meeting, members doing this assessment are cautioned to comment only on those areas in which they feel professionally competent. The influence of track features such as swithches, spurs, and frogs on the exposure of areas to hazard is reserved for comment by the Railways. Rankings or other quantifiable determinations of the degree of hazard impinging on areas surrounding different Subdivisions are to be avoided.

A wide variety of materials are provided to assist you. The full Hazard Assessment Package includes:

1. A set of Tables containing:
    a. estimated proportions of zoning types for the consequence zones, by Subdivision.
    b. a breakdown of population, employment, and other features, by Subdivision.
    c. a series of modelled and observed impact zones for several accident types, involving a variety of DC's.
2. Guide Map to the location of Railway Subdivisions within the City of Toronto.
3. Metro Toronto Map of Road Traffic Volumes at Major Over and Under- Passes along the North Toronto Subdivision.
4. Legend of Landuse Categories for City of Toronto 1971 Landuse Maps.

over...

5. Hazard Assessment Sets
   - each consists of three types of maps and tables.
   a. Rail Corridor Map
      - using the 1971 City of Toronto Landuse Maps (no more recent maps exist) as a base, the rail corridors, consequence zones, and topographic features are shown.

      Note: because several Subdivisions follow much the same route, a common map is used.
   b. Rail Subsection Data Sheets
      - this includes a schematic diagram of major track features along the Subdivisions
      - beneath the diagram is a table relating DC traffic volumes, population, and a variety of other factors.
   c. Population and Employment in the Consequence Zones
      - these combined maps and tables show detailed employment and duirnal variations in population for both consequence zones, on both sides of the railway tracks.

NOTE: In all cases, figures for the High Consequence Zones are included in the totals for the Moderate Consequence Zones.

Other Resources Available to you include:

1. Reference Table
   - this table is simpler than it looks.
   - the ranges of each of the factors displayed in items 5a and b above have been divided into quartiles. The head of each column shows the range and the quartile interval.
   - values of each factor in each subsection have been slotted into these quartiles.
   - a value of '1' indicates the highest values, '4' the lowest, and '4X' a value of 0.
2. City of Toronto Air-Photo Maps
3. Ministry of Natural Resources Base Maps
4. Standard Topographic Maps
5. Transparent Overlay of Radial Distances
6. Library of Reports and other materials

METHODOLOGY

As this is a subjective evaluation,highly precise methods are not absolutely necessary. Some room for individual creativity is available. Nonetheless, the following is a method which we suggest will allow a reviewer to move rapidly through the assessment while still producing valuable results.

over...

1. Examine the guide map to rail Subdivisions in the City of Toronto in order to get a geographic fix on the matter at hand.

2. Examine the package of background tables (#1) in order to grasp the general nature of population and landuse factors along each of the Subdivisions. Try to spot areas that have paticularly high amounts of 'special' populations.
   Look over the data provided on accident impact zones You may want to refer back to this data, in combination with the radial distance overlay, during later sections of the assessment.

3. Examine the Rail Corridor Map (#5a), in combination with the Legend provided to Landuse Classifications, to get a feel for the landuses found in the Consequence Zones. Note where topographic features have an influence on the Consequence Zones, Catchment Basins especially.

4. Based on the previous familiarization, move on to examine the Rail Subsection Data Sheets (#5b). Please note that each subsection has been given a four-digit identification number. Please use this number when referring to specific sections.
   Note: DC traffic volumes are included here not to imply any notion of accident probablity, but to indicate where there is hazard potential. The figures are intended mainly to provide background information.

   a. survey the figures provided

   b. take into account unusual concentrations of population, special features such as Schools and Hospitals, and residential zoning

   c. at this point, you may want to begin making use of the Reference Table in order to see where each subsection fits into the distribution of a factor,or number of factors, relative to other subsections along the Subdivision, or relative to City - wide distribution.

   d. to increase the detail available in evaluating population and employment, the maps dealing with these factors in the Consequence Zones (#5c) may be very useful, especially since they show data for either side of the rail corridor.

5. We encourage you, at whatever point seems most appropriate, to bring your professional expertise to bear on these issues.

6. As you come to determinations of whre hazard is most noticeable, and of what type of hazard it is, please write down your thoughts on the Hazard Assessment Forms. These forms have been broken down into several basic categories, for your convenience.

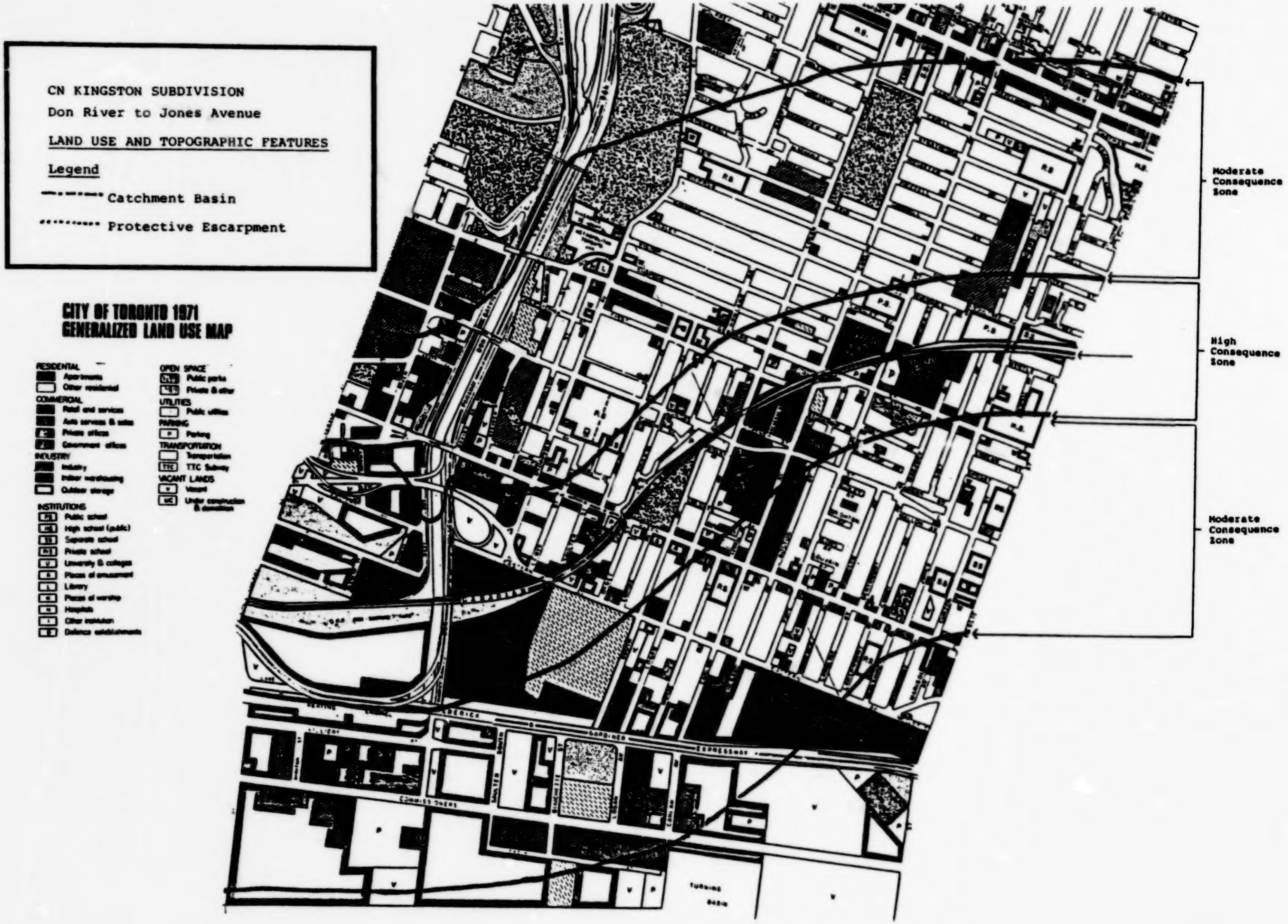
CN KINGSTON SUBDIVISION
Don River to Jones Avenue

LAND USE AND TOPOGRAPHIC FEATURES

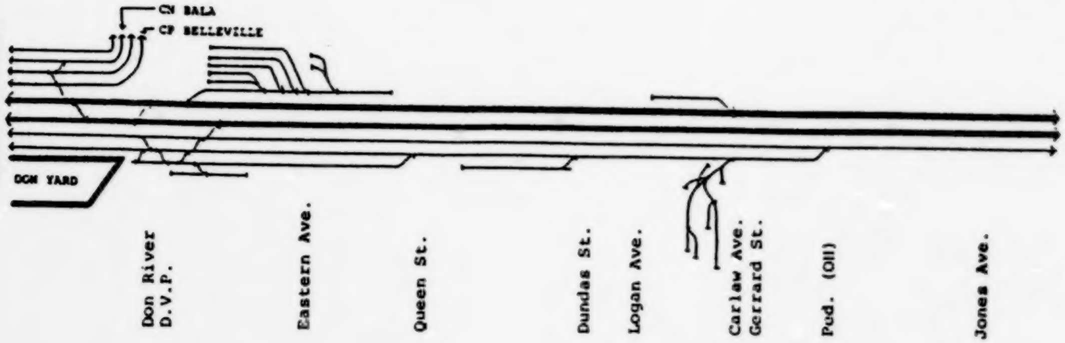
Legend

—·—·—· Catchment Basin

·········· Protective Escarpment


CITY OF TORONTO 1971
GENERALIZED LAND USE MAP
RESIDENTIAL
Apartments
Other residential
COMMERCIAL
Retail and services
Auto services & sales
Private offices
Government offices
INDUSTRY
Industry
Indoor warehousing
Outdoor storage
INSTITUTIONS
P.S. Public school
H.S. High school (public)
S.S. Separate school
Pr.S. Private school
U University & colleges
A Places of amusement
L Library
W Places of worship
H Hospitals
I Other institution
D Defence establishments
OPEN SPACE
Public parks
Private & other
UTILITIES
Public utilities
PARKING
P Parking
TRANSPORTATION
Transportation
TTC TTC Subway
VACANT LANDS
V Vacant
UC Under construction & demolition
Moderate Consequence Zone
High Consequence Zone
Moderate Consequence Zone
Turning Basin

CN KINGSTON SUBDIVISION
Don River to Jones Ave.
HAZARD ASSESSMENT DATA


CN BALA
CP BELLEVILLE
DON YARD
Don River D.V.P.
Eastern Ave.
Queen St.
Dundas St.
Logan Ave.
Carlaw Ave.
Gerrard St.
Pud. (OH)
Jones Ave.

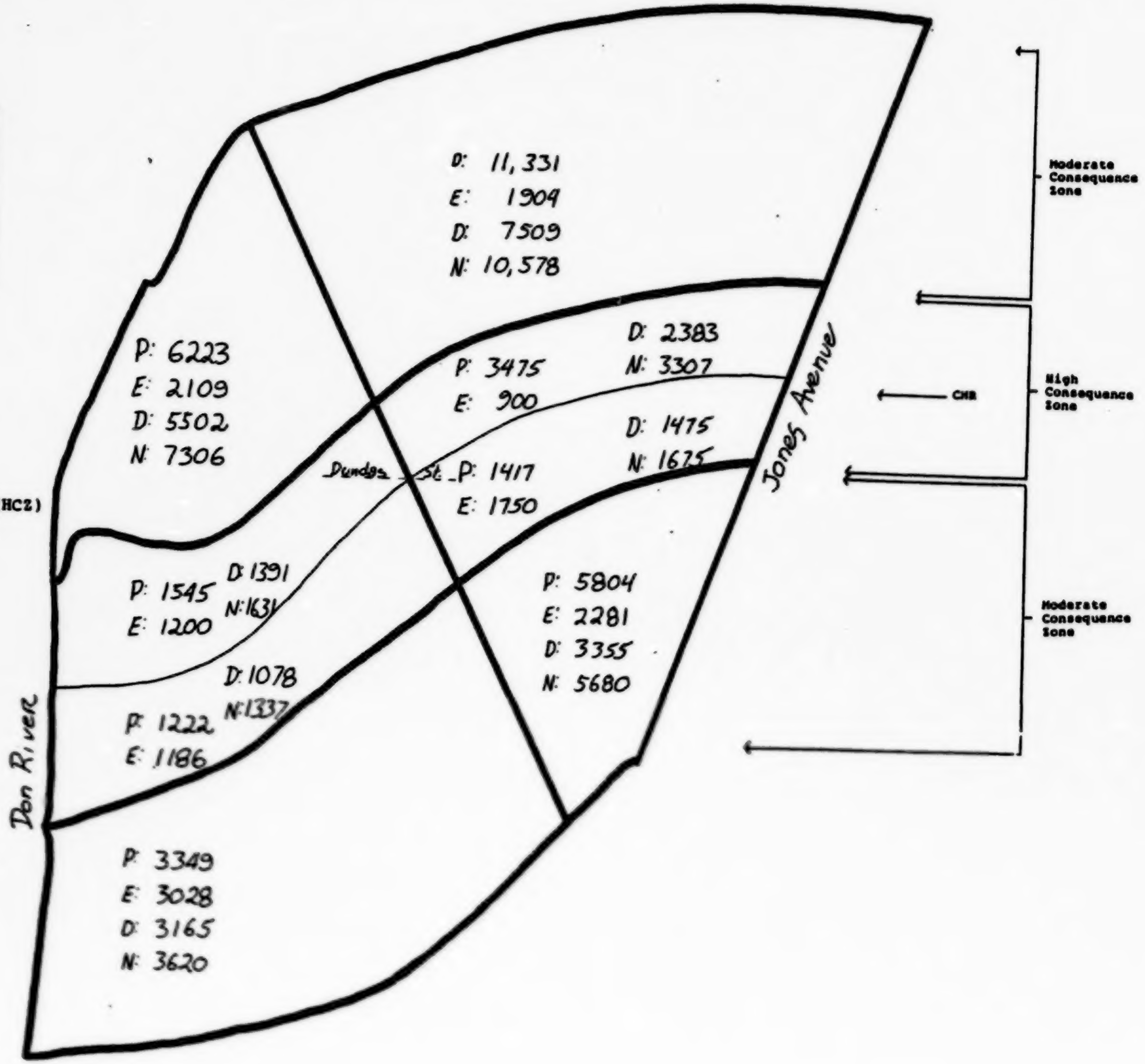
FACTORS		DON RIVER TO DUNDAS ST. (N1-01)	DUNDAS ST. TO JONES AVE. (N1-02)
RAILWAY FEATURES			
Annual D.C. Carloads		594	Same as (N1-01)
Annual S.D.C. Carloads		0	
All Other Carloads		58 604	
Total Gross Tons (000's)		15 080	
Other D.C. Data			
Persons per Metre Track Length (Day/Night)	HCZ MCZ	2.00/2.40 7.01/8.84	3.61/ 4.62 10.17/15.22
School Enrolment/ Hospital Beds	HCZ MCZ	207/0 1429/784 (plus 500 - jail)	801/0 3213/0
% Zoned Residential	HCZ MCZ	48 43	55 80
Topographic Features	%CB %PE	Catchment Basin (Don to Queen St. north side)	
Vulnerable Features			Gerrard Square abutting tracks; School abutting tracks
Evacuation Constraints			

CN KINGSTON SUBDIVISION
Don River to Jones Avenue
POPULATION AND EMPLOYMENT

LEGEND

- **P: Resident Population**
- **E: Employment**
- **D: Daytime Population**
- **N: Nightime Population**

NOTE: The figures for the High Consequence Zone(HCZ) are included in the total figures for the Moderate Consequence Zone (MCZ).


D: 11,331
E: 1904
D: 7509
N: 10,578
P: 6223
E: 2109
D: 5502
N: 7306
D: 2383
N: 3307
P: 3475
E: 900
D: 1475
N: 1675
Dundas St.
P: 1417
E: 1750
P: 1545
E: 1200
D: 1391
N: 1631
D: 1078
N: 1337
P: 1222
E: 1186
P: 5804
E: 2281
D: 3355
N: 5680
P: 3349
E: 3028
D: 3165
N: 3620
Don River
Jones Avenue
Moderate Consequence Zone
High Consequence Zone
CNR
Moderate Consequence Zone

ZONING IN THE RAIL CORRIDOR ACCIDENT CONSEQUENCE ZONES

By Rail Corridor, in Percentage of Land Area

Rail Corridor	Consequence Zone	R1	R2	R3	R4	Total Residential	C	CR	I	G	Total Non-Residential
Kingston	HCZ	0	50.5	0	8.2	58.7	28.2	0.8	5.5	6.8	41.3
	MCZ (Net)	1.8	66.3	0	8.1	76.2	13.5	0.5	4.5	5.3	23.8
	MCZ (Total)	1.3	61.8	0	8.1	71.2	17.7	0.6	4.8	5.7	28.8
Bala/Belleville	HCZ	16.8	2.4	1.9	6.6	27.7	18.1	0.5	8.4	45.3	72.3
	MCZ (Net)	15.8	24.7	17.8	6.4	64.7	6.4	1.0	18.1	9.8	35.3
	MCZ (Total)	16.1	17.4	12.6	6.5	52.6	10.3	0.8	14.9	21.4	47.4
Oakville	HCZ	2.2	3.8	3.0	21.1	30.1	7.9	0	16.0	46.0	69.9
	MCZ (Net)	5.2	13.7	5.9	18.8	43.6	9.9	0.5	9.3	36.7	56.4
	MCZ (Total)	4.0	9.8	4.7	19.8	38.3	9.1	0.3	11.9	40.4	61.7
Newmarket	HCZ	0	45.4	0	2.2	47.6	27.0	1.3	17.2	6.9	52.4
	MCZ (Net)	0	56.2	0	7.9	64.1	20.0	2.6	7.6	5.7	35.9
	MCZ (Total)	0	53.5	0	6.5	60.0	21.8	2.2	10.0	6.0	40.0
Galt/Weston/Mactier	HCZ	0	18.1	2.4	11.0	31.5	38.6	0.8	25.1	4.0	68.5
	MCZ (Net)	0	37.9	3.4	17.8	59.1	18.5	1.3	7.8	13.3	40.9
	MCZ (Total)	0	32.9	3.1	16.0	52.0	23.7	1.2	12.2	10.9	48.0
Galt/North Toronto	HCZ	10.1	34.0	1.9	1.4	47.4	30.4	4.5	9.1	8.6	52.6
	MCZ (Net)	21.1	44.9	1.9	4.4	72.3	12.6	5.1	2.7	7.3	27.7
	MCZ (Total)	17.9	41.8	1.9	3.5	65.1	17.8	4.9	4.5	7.7	34.9
Toronto Terminal Railways	HCZ	0	0	3.5	5.0	8.5	31.3	33.3	21.7	5.2	91.5
	MCZ (Net)	0	1.3	10.3	4.4	16.0	34.2	23.2	22.4	4.2	84.0
	MCZ (Total)	0	0.8	7.6	4.6	13.0	33.1	27.2	22.1	4.6	87.0
City Rail System	HCZ	4.7	25.8	2.0	8.5	41.0	25.5	5.5	12.1	15.9	59.0
	MCZ (Net)	10.9	35.8	3.3	7.2	57.2	17.7	4.7	10.9	9.5	42.8
	MCZ (Total)	8.7	32.2	2.9	7.7	51.5	20.4	5.0	11.4	11.7	48.5

NOTES:

1) Definitions:	R1, R2, R3, R4 = Residential; C = Commercial; CR = Commercial/Residential; I = Industrial; G = General (Open Space).
2) CR Zones:	CR Zones are Commercial/Residential but have been included with Non-Residential because the primary area of this zoning is the financial district where there is unlikely to be a significant residential component.
3) Toronto Terminal Railways:	The area of the Railway Lands and the Harbourfront has not been fully rezoned for future development. These figures assume rezoning to CR, R4 and G based upon projected land use.
4) MCZ (Net) and MCZ (Total):	MCZ (Net) represents the area between the HCZ boundary and the MCZ boundary and MCZ (Total) represents the total area between the railway tracks and the MCZ boundary.

APPENDIX E

Topical Bibliography

APPENDIX E

TOPICAL BIBLIOGRAPHY

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(ii) 1.B - Provincial Government
(iii) 1.C - Municipal Governments

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